THE

AMERICAN NATURALIST.

Vol. xi. — JULY, 1877. — No. 7.

NOTES ON THE AGE AND THE STRUCTURE OF THE SEVERAL MOUNTAIN AXES IN THE NEIGHBORHOOD OF CUMBERLAND GAP.

BY N. S. SHALER.

THE dogma of De Beaumont as to the parallelism of mountain chains of the same age has not lost its effect on the minds of geologists. The exceeding ability and untiring persistency with which its fallacies were urged has made it necessary to do more than refute them. Every instance of distinct contradiction should be well attended to and brought to the attention of naturalists. Having been trained in the theory of De Beaumont, I confess to having held to some remnant of faith in his views until I began my studies on the Appalachian system of mountains. Having examined this system in a preliminary way, throughout its extension from Gaspé to Georgia, I am convinced that as far as we can base our conclusions on the structure of one mountain system, it would be nearer the truth to say that mountain systems are more likely to be the product of parallel upheavals occurring in successive geological periods than of single epochs of elevation.

Some years ago I called attention to the fact that the Cincinnati axis was an outlier of the Appalachian system, and that it was formed, in part at least, as far back as the calciform sand rock of the Upper Cambrian period; also that the syenite axis on which Richmond, Virginia, now stands was uplifted after the general elevation of the Alleghanies had taken place,[1] since the formation of the Richmond coal-basin, and therefore must be referred to a time subsequent to the Trias if not to the Lias. The Blue Ridge was certainly elevated, at least in part, before

[1] I have since found that the parallelism of the Cincinnati axis with the Appalachian system had been previously noticed by Prof. J. M. Safford, State Geologist of Tennessee.

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the formation of the Appalachian coal-field, so that the east and west section, from the Mississippi River to the sea across the Appalachian mountain system, gives us evidence of four distinct periods of elevation, the separation of which is recognizable on even a cursory inspection. I was not prepared, however, to find the additional evidence of the succession of elevations which has been given me by the study of the region lying between the Unaka Mountains of North Carolina and Central Kentucky. The work of the Kentucky Geological Survey in connection with the Harvard Summer School of Geology ranged during the last two summers over this area. As the results of this exploration must wait, it may be, some years before publication, I shall summarize some of the most important points that bear on this question.

The geologist who is accustomed to the aspect of the Alleghanies in Pennsylvania will be struck with the change in the appearance of their continuation in East Tennessee. In place of the long-drawn symmetrical arches of the Pennsylvania section, we have here in East Tennessee a great irregular table-land crossed from north to south by narrow wall-like ridges, which have, in some cases, a length of over one hundred miles. A close study of the country shows that these ridges are in most cases the more or less retreated walls of fault lines, which have a singular directness in their course and uniformity in the depth of their throw.

The increase in the amount of faulting that took place in the formation of the Alleghany Mountains south of Pennsylvania becomes perceptible as we pass the Potomac River. In the mountainous regions of Virginia, along the waters of the south fork of that river, it begins to mark itself on the topography, and the change continually increases as we pass toward East Tennessee. Although still much in doubt as to the nature of the influences which have brought about this change, I venture to suggest the following explanation, which seems in a measure to satisfy the conditions of the problem.

On looking at the sections exposed in Southwestern Virginia and Eastern Tennessee, it will be seen that there are two classes of ridges found in this district: one formed by faults and the other by escarpments of the retreating crest of the anticlinals. It will be seen that the fault ridges have been formed on either side of the anticlinal ridges, though there is but one considerable ridge formed in this manner on the western side, while there

are three or more on the eastern side. After a good deal of consideration of these peculiar features, I have come to the conclusion that this change of the structure on the southward extension of the Alleghanies can best be accounted for by assuming the following conditions: First. That in place of the relatively narrow ridges of the Pennsylvania district, the uplifts which occurred here took the shape of one or more very broad anticlinals having a transverse width of sixty miles or more. Second. That each of these anticlinal axes was fractured by faults along several lines for its whole length, the result being to tumble the fissured strata over each other, leaving only the central part of the anticlinal still complete. Third. That the more massive the Blue Ridge to the eastward becomes, the more intense do we find this faulting action, on the east showing some relation between this faulting and the mass of the old mountains. I have long been of the opinion that the faulting in any mountain region becomes greater as the anticlinals widen or tend to take on some of the characters of the Alpine "massifs." It is not difficult to imagine a reason for this general occurrence of faults in broad folds of mountain masses; a small fold may have some sustaining power to its arch, and can await the gradual movement of strata to fill up its suddenly formed cavities. A broad fold will necessarily be weaker; the creeping of the strata into positions fitted to sustain the uplifted ridge may not be quick enough to keep furrows from forming, as they have formed in this Tennessee district.

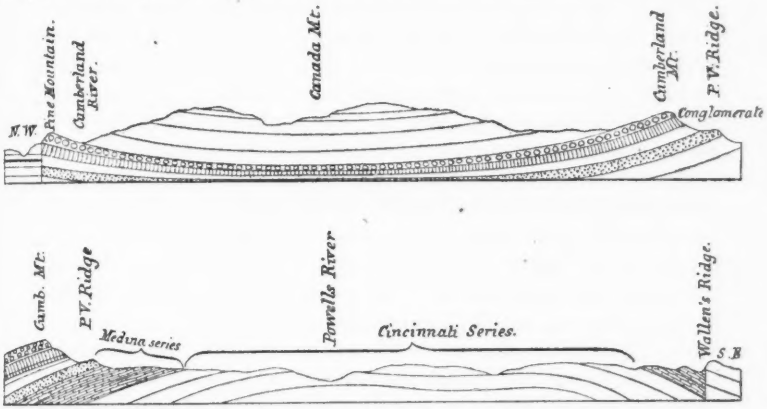
It is not so easy to perceive a reason for the greater width of the anticlinals in this part of the Appalachian chain. There are, however, good mechanical reasons why the width of the ridges and furrows which make up a mountain range should have a width proportionate to the depth of the strata involved in the movement. An illustrative experiment showing the principle that determines this is easily made by taking a number of sheets of heavy paper and compressing them from the sides. The more sheets we affect by the pressure, the broader the resulting folds will be.

In any region where successive mountain upheavals have taken place, as in the Alps, there is often evidence going to show that the lateral force operated at first to disturb the more superficial beds, and then in succession the deeper ones became affected. It is this, I believe, that gives us the Swiss *massife* plan of mountain-building. I conceive that in the Alpine region there was first a set of folds after the essential plan of the Jura Mount-

ains, then at a succeeding time there was an upheaval that affected a deeper set of beds and formed far wider folds, on which the earlier uplifts were upborne as the lesser waves of the sea upon the greater ridges. At the same time the broader folds were much faulted, so that the whole mass became exceedingly complicated in its structure. The Appalachian system, in its extremely varied yet comparatively simple conditions, presents us with a number of peculiar connections and separations of these two classes of folds. The Cincinnati axis, for instance, is a sample of the broad fold of the simplest character. This fold seems to have been lifted with extreme slowness, and has a height of only a few hundred feet, being certainly not over fifteen hundred feet in height at any part measured from the bottom of the synclinal to the top of the ridge. But notwithstanding the slow formation and moderate elevation of this fold it has been somewhat affected by faulting in a direction transverse to its axis; these faults are, however, relatively very small. It seems to me that the East Tennessee region has had its form given by an effort to produce very broad and long anticlinals somewhat on the Cincinnati model, but of far greater height. One of these ridges, the Cumberland anticlinal, if it had retained its form, would have had a length exceeding one hundred and fifty miles, a width of sixty miles, and a height exceeding twelve thousand feet. The parallel faults reduced its height to less than half this height, and left an indistinct central anticlinal and a set of parallel fault mountains, one on the west, and four or more on its eastern side. According to the theory of De Beaumont these several mountain ridges, the central anticlinal and its several parallel monoclinal or fault-mountains, should have been of the same age, the product of a single cataclysm. The evidence, however, has led myself and my assistants of the Summer School of Geology and the Kentucky Survey, who have studied this country, to a very different conclusion. We have been forced to the conviction that the central anticlinal is of relatively ancient age, dating back primarily to a time soon after the expiration of the carboniferous time, while the other monoclinal mountains have been more or less gradually formed, some having been uplifted at a geologically very recent date. This succession has been determined by the only means we have of fixing the age of neighboring parallel faults in a region of this description, namely, by comparing the rate of the escarpments formed by the several fractures. The central escarpments, as will be seen from the accompa ying figure, there covering the

anticlinal, have gone back as much as six or eight miles from the top of the arch, while the lateral escarpment of Pine Mountain has not retreated more than half a mile from its original place. After making all due allowance for possible differences in erosion rate of the two forces, it will be impossible to believe that erosion has acted on these two faces for equal lengths of time. There can be no doubt left in the mind of any one who studies these escarpments and satisfies himself of their relation to the geology of the neighboring districts, that their outcrops were made at periods widely remote from each other.

If there should be any need of accumulating proofs on this point, they could be found in a number of other circumstances



(Fig 70.) DIAGRAMMATIC SECTION ACROSS THE CUMBERLAND SYN-ANTICLINAL.

connected with them. The Pine Mountain fault, for instance, is characterized by a wonderfully rectilinear front, being hardly swerved from a straight line in fifty miles of its length. Throughout this distance the fault that made the escarpment is hardly half a mile from the summit of the crest. The Cumberland Mountain, which is an anticlinal escarpment, is an exceedingly irregular line, often departing as much as a mile from a direct course, and cut through and through at many points by streams. These irregularities in the one case and the regularity in the other attest the difference in the age of the two escarpments. There is still other evidence, the nature of which, however, it is not easy to make plain in a few words. This evidence may be briefly stated as follows: The streams on the west which head against the Pine Mountain are generally characterized by a

singularly low rate of fall; in several cases they run for miles without the least contact with their bed rocks, in fact with many feet of alluvial strata between their beds and the rock in which their troughs are excavated. I have been unable to explain this peculiarity save on the supposition that the district through which these streams course has been somewhat lowered by the movements which formed the Pine Mountain fault. If this be really the case, then we are compelled to suppose that the later movements of this dislocation — if the dislocation has indeed been, as I am disposed to believe, the product of a series of movements, — must have taken place after the drainage of this country had been entirely established, when each crest ran on its present line. I am led to the opinion, all the evidence being taken into account, only a part of which I can discuss here, that the escarpment of the Pine Mountain fault is now retreating from the line of breakage at the rate of not less than one foot in one hundred years. The rocks comprising the abrupt declivity are of a generally perishable nature and wear out readily under the action of frost and rain. This rate of retreat would give an age of not over five hundred thousand to one million and a half of years as the time that has elapsed since the formation of this fault. I am quite well satisfied that this estimate for the antiquity of the Pine Mountain fault is far within the truth, that it is in fact the result of disturbances which came in the time of the later Tertiaries.

I hope to elaborate these observations on the conditions of the Alleghany system in the Memoirs of the Kentucky Geological Survey; at present it is only possible to set forth the evidence in the briefest manner, with the special aim of calling the attention of students of physical geology to the evidences of recent action in the mountain-building forces in this part of the Appalachian district. I am confident that, more than any other mountain action known to me, they tend to show that the strains which are relieved by mountain folds and faults are, in certain cases at least, continuous actions leading from time to time to movements that afford relief thereto. No one can study the structure of the section between the eastern face of the North Carolina mountains and the western side of the Cincinnati axis without being driven to the hypothesis that in a geological sense the mountains contained therein have been in a process of continuous formation since the beginning of the lowermost Cambrian deposits. Perhaps less distinctly shown, but it seems to me quite clear, is the evidence

that the relief of these mountain-building barriers has been found in two ways: First, by the folding of the earth into ridges and valleys, or synclinals and anticlinals; second, by the forming of faults which are the product of the rupturing of the folds, and must be regarded as resulting from the failure of the lower lying rocks to follow and support the more superficial beds in their upheaval. This failure may have been in part caused by the exceeding width of the upthrown ridge, which could not maintain itself until the deeper beds could adjust themselves to support it.

When we consider the numerous cases in this district where the drainage crosses faults of many thousand feet of throw, we are driven to the belief that whole geological periods have been required for the movements involved in their formation. I am inclined to believe, however, that while the greater part of these dislocations have been made slowly, some of them have been formed with a great suddenness, and attended by movements of extreme violence. Besides the faults traversed by streams whose courses have not been turned or interrupted by these gigantic dislocations there are others which exhibit unequivocal evidence of violent movement in their formation. These evidences are various in their nature, but they are most conspicuous in the shattering of the walls on either side of the fault. The best instance of this sort of disturbance is found about the fault which passes through Cumberland Gap, and by the weakness it has given to the rocks has brought about the formation of this mountain pass. This remarkable fault is marked by the presence of a belt of rock fifty feet or more in width, which has been fractured into a breccia by the violence of the movements which have attended its formation. The breccia is cemented by an infiltration of iron derived from the adjacent carboniferous series of rocks. A careful study of this breccia has convinced me that the fault is the product of many successive movements, though each of them must have been attended by a certain beating of the walls against each other. This fault, it should be noticed, is transverse to the direction of the great faults in this system of mountains, and is limited to the Cumberland synclinal, extending from a little beyond Cumberland Gap on the east to the gap in the Pine Mountain at Pineville. It differs also from the great parallel northeast and southwest faults which we find at Clinch Mountain, Mound Hill, and other points, in the irregularity of its throw, which differs not only in amount but in direction in a curiously irregular way. I believe that it owes its formation to the com-

pression strains which take place in the synclinal fold of the Cumberland. It is readily to be perceived that the nature of the strains developed by the synclinal folds must vary greatly from those which are formed beneath the anticlinals of a mountain district.

I only propose to call attention to the great problems in structural geology which this region presents to us, with a view of interesting our students of dynamic geology in their solution. More extended discussions of these questions will be given in the forthcoming volumes of the Memoirs of the Kentucky Geological Survey.

THE STUDY OF ZOÖLOGY IN GERMANY.

BY CHARLES SEDGWICK MINOT.

II. THE METHODS USED IN HISTOLOGY AND EMBRYOLOGY.

THE use of the microscope goes hand in hand with the work of zoölogists in Germany, and it is there that we find the greatest number of means employed to render the objects suitable for examination. I have frequently heard American zoölogists express a slight distrust of histological methods, — well founded, perhaps; it ought not to lead to the rejection of the benefits to be obtained from using them, but merely to greater caution in employing them.

It is well known that animal tissues and organs consist of cells of various kinds, variously grouped together. The forms which these cells can assume lead to the most curious transformations, so that things as different from one another as muscular fibres, blood corpuscles, and ganglion cells can be traced as modifications of the same primitive form. The work of microscopic anatomists is to detect the changes which the simple cells of embryos undergo in the course of their transformations into the components of the tissues of the adult, and to investigate in detail the final results of these metamorphoses. It is much to be desired that America should assist more in this work, and it is with the hope of stimulating some persons to do so that this article is written.

In the tissues of the adult we find the cells arranged in a definite manner, and we have consequently to examine the shape and character of the single cells, and then their relation to one another. Simply placing a small piece of an organ underneath

the microscope is not sufficient to enable us to do this, but we are obliged in every case to subject the preparation to a special treatment. The first thing to be done is to make the object transparent enough to let the light pass through it to the objective, which is usually done by mounting it in glycerine or in Canada balsam, both of which substances have a high index of refraction, and therefore when they penetrate the interstices of a tissue do away with the refraction inside of it, so to speak; for in every tissue the different parts refract the light so variously that a ray passing through frequently changes its path, thus confusing the final image which reaches the observer's eye. A layer of powdered glass lets the light pass through, but nothing distinct can be seen; if, however, the whole is immersed in Canada balsam, it immediately becomes beautifully transparent, because the balsam fills up the spaces between the bits of glass, and since balsam and glass refract light to about the same degree the mass becomes optically nearly uniform, and a ray of light can pass through it without being deviated from its course or destroying the image. The action on the tissues is identical, — and this should be carefully remembered, because balsam renders objects more transparent than does glycerine, so that in some cases one liquid is better than the other. It is a sign of inexperience to assert that balsam is better than glycerine, or *vice versa*, for they are both useful, but for different purposes.

In order to observe the cells well it is necessary not to have too many superposed layers in the field of view, but to make the object as thin as possible. This is usually accomplished by making sections. So important and so useful are such very thin slices that probably nine tenths of every histological collection consist of them. The first thing, therefore, is to acquire skill in making sections, and the perfection reached will mainly decide how far the progress of the student shall continue. The importance and benefits of making sections have led to the invention of a great many mechanical contrivances for cutting them. One form of cutter or microtome well adapted to its object was described in the April number of the NATURALIST of this year. Numerous other forms have been suggested, but those with which I am acquainted all have some defects. Free-hand cutting still remains absolutely indispensable. It may be acquired by patient practice even by those who have no special manual skill, just as we are all able to write. There are many things which cannot be cut with a machine. The razor for cutting should be

of the best quality, and when used always drawn towards the body, while the surface, which looks downward in cutting, must be flat. The edge must be perfect, the slightest notch being sufficient to tear a section to pieces, and so sharp that a human hair can be split with it. The sections themselves must be as thin as possible.

Since all parts of the body, with few exceptions, such as the skeleton, etc., are soft and permeated by water, besides possessing great elasticity, they cannot be cut in their natural condition; it becomes necessary, therefore, to harden the organs. Now protoplasm is the main constituent of cells, and itself consists chiefly of albumen. This substance can be coagulated by the action of various agents, some of which can be applied to the tissues without injuring them, to produce a coagulation of the albumen in its natural form within the cells.

Alcohol is one of the most valuable agents for this use. It produces its effect by its strong affinity for water, which it can withdraw from the tissue, thus causing the albumen, which requires an abundance of water to maintain its semi-fluid state, to solidify. It may be employed for the majority of tissues with perfect success. The volume of alcohol should be from twenty to thirty times that of the object to be hardened; weaker alcohol, say of eighty per cent., should be used first; after a sojourn of an hour or two, or even longer, if large, the object may be transferred to stronger (ninety-six per cent.) spirit and there left for twenty-four hours, more or less, according to the size of the piece. The great difficulty in the use of alcohol is to prevent the shrinkage which naturally follows upon the abstraction of the water from the tissues. This may be avoided by using first weak, and then strong, and finally very strong spirit. In some cases the action is not even then sufficient, and recourse must be had to absolute alcohol, which generally produces the desired result.

When even that does not succeed the specimens may be put in picric acid (concentrated cold aqueous solution) for twenty-four hours, then in a syrupy solution of gum arabic for twenty-four hours, and finally in strong alcohol again for the same length of time. The picric acid removes the alcohol, and allows the gum to penetrate the object, within which it is finally coagulated by the last dose of spirit. The sections when made must be left in water for a day, to dissolve out the gum which they still contain, and which renders them quite opaque. A very few

drops of strong carbolic acid may be added to the water to prevent the development of bacteria, etc., which would quickly ruin the preparations. Coagulated gum renders the majority of organs of a pleasant consistency for cutting.

Instead of gum, paraffine may be made to permeate the tissues, in the way already described in detail in the article on the sledge microtome, in the April NATURALIST.

All acids produce in albumen chemical changes, which, without withdrawing the water, cause coagulation. There are some which are admirably suited for hardening agents. Foremost among these is chromic acid, first introduced by Hannover, in 1841, from motives of economy. It is employed in solutions of two fifth parts for one thousand parts water. Very large quantities must be used, — weak solutions at first to be gradually replaced by stronger and stronger ones. If its action is kept up too long the objects become brittle and are then worthless, for every section crumbles to pieces as soon as made. Chromic acid is particularly useful in studying nervous tissues, organs of sense, and other unusually delicate tissues. Its action is very slow: thus the spinal cord of a large dog or a man requires at least six weeks or two months. Chromic acid is also admirable for preparing very young and frail embryos or eggs. There are many other agents which are sometimes used for hardening, but it is not deemed appropriate to enumerate here any but the two principal and most useful ones, alcohol and chromic acid.

After the proper degree of hardness has been produced, if the piece to be cut is large enough, it may be held in one hand and cut with the other without more ado. When, however, we have to deal with something too small and delicate to be held in the hand, it is necessary to have recourse to some method of imbedding. Paraffine will usually be found the most convenient substance for this purpose, especially when mixed with one tenth of its weight of the best hog's lard. The most satisfactory process of imbedding in paraffine we have elsewhere described.[1]

On some accounts transparent soap is to be highly recommended. The best quality, containing *no glycerine*, must be chosen, then shaved into small bits, and warmed with half its volume of alcohol (as compared with it before it was cut up) until it is entirely dissolved; the specimen to be imbedded is then suspended in the warm mass by a fine thread and left for

[1] April NATURALIST, 1877, page 208.

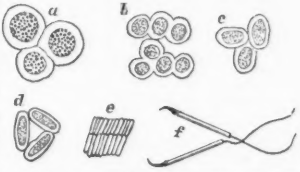
twenty-four hours. The soap does not become hard until the alcohol evaporates from it; the less alcohol, therefore, put in originally, the better. The soap ought to remain perfectly clear, enabling one to see the imbedded specimen within, so that it can easily be observed exactly in what plane every section is made, which is not possible when paraffine or wax is used. The sections, when made, if cut in soap, must be put in alcohol, if from paraffine, in spirits of turpentine, to dissolve out the remains of the imbedding mass.

If now the sections, after being thus freed from the adherent foreign matter, be mounted directly, they make poor preparations; the single parts are indistinct, and the whole is very transparent. This can be avoided by coloring them. It may be safely asserted that the introduction of staining fluids, by Gerlach, in 1858, was the most important step in advance ever yet made in histological technic. Coloring matters, as regards their action on cells, belong to two classes: either they produce a diffuse coloring of the whole cell, or they stain the nucleus much more deeply than the protoplasm and the membrane of the cell. The principal are dyes of the latter class, carmine, hæmatoxiline, and aniline blue, which are esteemed in the order named. The two former are invaluable, for by marking out the nuclei so distinctly they enable us to recognize so many centres of cells, and to observe characters which have been made prominent by their coloration, and are very different in the various forms of cells. In fact, preparations for the microscope cannot be felt or dissected, but only seen; therefore, the differential coloring produced by carmine, for example, is an assistance to the eye, comparable to the raised alphabets of the blind. In both cases, the conditions under which the special sense, whether sight or feeling, has to act are greatly exaggerated, so to speak, thus producing magnified or strengthened perceptions.

Carmine is by far the most generally useful. It is employed in various solutions, the recipes for which may be found in various hand-books, and need not, therefore, be quoted in this article. The first step in preparing it is to dissolve some of the fine-powdered carmine in a small quantity of ammonia, and it may be used at once in that form after allowing the superfluous ammonia almost entirely to evaporate. A very excellent solution may be prepared by simply adding an equal volume of rather strong acetic acid to the dissolved carmine; the exact proportion is not of very great import. Beale's carmine keeps a long time

without alteration, and Ranvier's picrocarmine has certain advantages; but on the whole, I have found the above-mentioned mixture of acetic acid and ammoniacal carmine to be quite sufficient for most work.

Hæmatoxiline, on the other hand, has to be employed in a particular solution. Dissolve first thirty-five parts of hæmatoxiline crystals in one thousand parts of absolute alcohol, and mix it cold with a solution of ten parts alum in three thousand parts distilled water. The mixture is purple at first but turns a deep blue in the course of a few weeks; but it may be used without waiting for the change of color. For use it must always be filtered through porous paper to free it from sediment, and it may be advantageously diluted with 0.5 per cent. solution of alum. It acts much more quickly and produces a deeper and more exclusive staining of the nuclei than does carmine. It is therefore particularly applicable in those cases where it is desired to study the shape and transformations of nuclei, as, for example, in tracing the development of spermatozoa. A figure is here added to show how beautifully the changes can be followed in sections of the testicle of *Epicrium glutinosum*, one of the Cœciliadæ or footless, worm-like amphibians. The testicle is divided up into numerous follicles, and the cells in each are all in one stage, while the various follicles present various degrees of development; thus in a single section all the principal alterations may be observed. The cells (Figure 71) are round at first with a very large granular nucleus (*a*). They then divide, becoming smaller and more numerous (*b*). The next change is a slightly irregular elongation of cell and its nucleus, slight at first (*c*), but gradually increasing (*d*).



(Fig. 71.) DEVELOPMENT OF THE SPERMATOZOA OF EPICRIUM GLUTINOSUM.

At this point in the metamorphosis the protoplasm is gathered at one end of the cell, and the long nucleus at the other, and it at once becomes evident that the nucleus is to make the head of the spermatozoön, the protoplasm the tail. At this stage the cells lay themselves in rows (*e*), the nuclear ends, or as we may now call them the heads of the young spermatozoa, all pointing the same way. Each cell continues to elongate until it grows into a fully developed spermatozoön (*f*), with a pointed front end, a long head which appears almost black when stained with hæmatoxiline, and a long, fine tail. The development of the

spermatozoa seems to be very much the same in all vertebrates; that is to say, the primitive cells of the testicular follicles divide into smaller cells, and the nuclei of these make the heads, while their protoplasm changes into the tails of the spermatozoa. We have spoken of these changes here because it is proposed that the next paper shall be on the development and early stages of eggs, and there will be occasion to refer to the observations just quoted.

It is well known that cells create certain products which appear outside of the cells themselves; thus wherever there is a layer of cells having a free surface, as, for example, the outside of the body of invertebrates or the walls of tubes such as ducts of glands, the digestive canal, etc., they tend to form a structureless membrane, which stretching over them all acts as a common protective covering. The hard crust of insects is such a membrane or *cuticula*, and a corresponding one lines the tracheæ and the stomach, etc., of insects and many other animals. Now the application of section-making to the study of *cuticular* growths reveals many interesting peculiarities; as this study is only just entered upon, it is hoped that a reference to some of the results may prove valuable.

M. Léon Dufour described curiously shaped teeth in the crop of certain crickets, especially well developed in the mole-crickets, very large also in the katydids. Herr Wilde, of Leipzig, has made a very thorough study of these teeth and their development; he kindly showed the author many of his preparations, and explained his results. He made numerous beautiful sections of the crops of several species, both young and adult. Figure 72 is taken from one of his sections of the crop of *Gryllus cinereus*, the European field cricket. There are six teeth of very irregular shape, with many protuberances, but presenting, nevertheless, the general outline of a triangle, with the apex towards the middle. On each side of the projecting apex are two protruding points, at the base of which there is a bundle of stiff chitinous bristles. Between every two of these gigantic teeth there is a small ridge (*r*) which also has a hard cuticula. Further, the teeth are not

(Fig. 72.) TRANSVERSE SECTION OF THE CROP OF GRYLLUS CINEREUS.

attached along their whole base, but are partly drawn back, so that there is a space (*sp*) between the middle of the base and the muscular walls of the crop. The teeth form six regular, longitudinal rows, numbering each about twenty teeth. Their form varies according to the genera, and probably also according to the species. The walls of the crop are built up mainly of circular muscular fibres (*muc*) which by their contraction drive the teeth towards the centre and so grind up the food of the cricket, thus performing a function which we are wont to think of as properly belonging to the mouth. The study of the development of the teeth enabled Herr Wilde to ascertain that they are formed by underlying cells through a series of transformations of the cuticula, which appears at first as a simple membrane and then develops the secondary projections, which give the teeth their ultimate form. All these interesting discoveries could hardly have been made except by means of sections.

The author has himself applied section-making to the study of the tracheæ of insects.[1] It was found that the current descriptions in works on comparative anatomy and entomology were incorrect in several important particulars. The outside of the trachea is covered by a layer of flat polygonal cells, or, as it is called, a pavement epithelium. Thus in a longitudinal section of the main tracheal stem of the common water-beetle, *Hydrophilus* (Figure 73), the thin cells (*ep*) may be easily recognized by their nuclei. The epithelium secretes the enormously thick and complicated cuticula (*cu*) which makes up the rest of the tracheal wall. The well-known spiral threads or filaments *ff* are part of this cuticula, and not distinct structures as was generally supposed. These threads run around the tubes and serve as elastic supports to keep the thin walls distended; they are more or less spiral, but instead of there being but one single thread, as is usually stated, there are four or five which end, after making a few turns around the tracheæ, new ones arising to replace them. As the fibres run transversely, of course their cut ends only are seen in a longitudinal section like Figure 73. But these ends show that the filaments consist of a lighter outside, and a darker inside portion, which latter is round. The rest of the cuticula (*cu*) is divided into two layers,

(Fig. 73.) LONGITUDINAL SECTION OF THE TRACHEA OF HYDROPHILUS PICEUS.

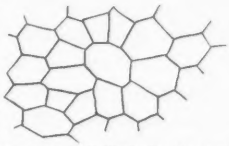
[1] Minot, Recherches histologiques sur les Trachées de l'Hydrophilus piceus. Arch. de Physiol. normale et pathologique, sér. ii., tom. iii., page 1.

the inside or right hand one in the cut, being slightly colored by carmine, while the outside layer is hardly stained at all. This affords another excellent illustration of the ease with which valuable discoveries may be made, when well-known histological methods are applied to the study of insects; indeed, insects offer a rich and easily accessible field of research, promising perhaps greater rewards in proportion to the necessary labor than almost any other department of zoölogical investigation.

It would be easy to add illustration after illustration to those already given, but it is not our purpose to review the progress of histology, but merely to give incentives to work in that field. We pass on, therefore, to a few additional considerations on the "technique" of preparing tissues for microscopical examination. Experience has shown that it is very difficult to distinguish the single cells in sections, in some case almost or quite impossible; or it is even impossible occasionally to make any sections at all. On these accounts various means are employed either to isolate a few cells or to mark the outlines of them. The methods hitherto employed for these purposes are few in number and limited in application, but they have already led to interesting observations.

Many cavities of the body, both of vertebrates and lower animals, are lined by a layer of flat cells that are separated by lines of intercellular substance; by treating such a surface suitably with certain silver salts the intercellular lines are colored dark brown or black. A solution of one part of nitrate of silver in five hundred parts of distilled water (by weight) is very convenient. It gives beautiful preparations when applied to the mesentery of a rabbit, for example. The mesentery is the thin membrane by which the intestine is suspended from the back of the abdomen. Cut out a small piece from a freshly killed animal, a frog or rabbit or any other vertebrate, and place it in a silver solution, where the direct rays of the sun can fall upon it, and move it about with a glass rod (metal would be corroded) so that all parts may be equally acted upon; next remove it for a moment into distilled water to wash off the silver, and then spread it out on a glass slide and let it dry almost completely, taking great pains to stretch it out by pulling it at various points so that it shall dry *fully* extended. Before it is quite dry put on a drop of glycerine and a thin glass cover in the usual way. If the impregnation has been successful, the lines will appear very sharply, as in Figure 74, which is from the mes-

entery of a turtle. If the impregnation was not sufficient the lines do not appear, but that is also the case if it has been too prolonged, for then the cells fall off altogether. The membrane may be colored with hæmatoxiline or carmine, if so desired, after impregnation, and then the stained nuclei appear within the dark outlines making exceedingly pretty preparations.



(Fig. 74.) MESENTERY OF TURTLE. SURFACE IMPREGNATED WITH SILVER.

Maceration gives the means of isolating layers of cells. If the skin of an amphibian, a toad, for example, be pinned out on a bit of cork and then placed in a dish of water containing three or four drops of strong carbolic acid to prevent the development of germs, and then left for a day or two, the superficial layer of cells may be peeled off with a pair of pincers, and so on, successive layers from day to day until the whole skin has been removed. The bits thus peeled off usually contain but a single layer of cells, and if colored with carmine they make very beautiful preparations.

But besides investigating cells in their relation to one another, the histologist endeavors to determine the form of single cells, and employs therefor means of isolation or dissociation. These may be either mechanical, such as shaking up a tissue in a fluid or teasing it out with fine needles, etc., or chemical. Usually a combination of the two is the most effectual.

In most tissues the cells are united by intercellular matter, just as above described in the epithelium of the mesentery. This substance acts as a cement binding the cells together. In some cases it reaches an extraordinary development, so that the cells come to be quite far apart, as in cartilage, for instance. But usually it is very thin, and may be dissolved, in some cases, without altering the appearance of the neighboring cells. The cells that line the intestine and stomach are particularly adapted to illustrate this action of certain chemicals. Thus if a small bit of the wall of the digestive canal be left in alcohol of thirty per cent. for twenty-four hours, the lining cells all become loosened so that they are easily scraped off with a needle or scalpel, and if mounted in glycerine mixed with a little picrocarmine, they become stained in a week or so, and show the details of structure of the single cells very admirably.

Chromic acid has a similar action, and solutions of two parts in ten thousand of distilled water have a great value from their so

affecting the brain that the ganglion cells may be quite easily isolated. To effect this a very small piece of the brain — calf's brain is perhaps the best — is placed in fifty or sixty times its volume of the solution for twenty-four hours, and then carefully teased out under a good dissecting microscope.

Both weak chromic acid and alcohol may be used for isolating muscular fibres. Flies and beetles are perhaps the best for this purpose. The muscles of the wings (not those of the legs) should be torn out with fine forceps, and little bits, the smaller the better, placed in thirty per cent. spirit for twenty-four hours, and then dissociated or pulled apart on a glass slide, with fine needles. With sufficient care it is possible to separate the single fibrillæ of each fibre, and when stained with hæmatoxiline the alternating lines, dark and light (Figure 75), appear very sharply. These lines are those that make the muscles transversely striated. The cause of this striated appearance is not yet fully determined, but it is apparently connected with greater perfection of the muscular fibre than is found in the unstriated form. Different as is muscle in appearance from cells yet it originates from them, and is in fact formed of metamorphosed cells, by a series of changes all as great as those which produce bone.

(Fig. 75.) ISOLATED MUSCULAR FIBRE OF COMMON WATER BEETLE.

We have still to notice a very important class of procedures, namely, injections. In the higher animals we find two distinct sets of vessels ramifying through the whole body: one of these is the system of blood-vessels, the other the lymphatic system. As is well known to all, the blood-vessels branch out into very fine tubes that form a complicated net-work in every part of the body, so fine that it can only be followed when the tubes or capillaries have been artificially filled with a colored matter. The same is true of the lymph-vessels, but to an even greater extent. Many of the structures of the body are permeated by connective tissue, and in this tissue there are numerous cavities filled with fluid; they are in communication with very delicate tubes, the lymphatic capillaries, which soon unite into larger canals, and these form branches which gradually join together and lead to the thoracic duct or main stem, which empties into the veins just before they open into the heart. The branches of this tubular system are provided with valves so arranged that the liquid contained in the tubes can only pass upward or towards the main stem. Now when any

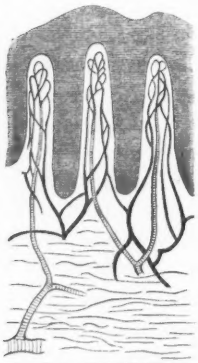
motion takes place, some of the liquid in the cavities of the connective tissue is pressed into the lymphatics and so slowly driven onwards into the heart. To counterbalance this loss of intercellular fluid, certain constituents of the blood exude through the walls of the capillaries and keep up the supply. There is, therefore, a double circulation: one within the blood-vessels, and another from the walls of the capillaries through the lymphatics. The liquid in both circulations is ultimately returned to the heart.

Different methods have to be employed for injecting the two systems. In the case of the blood-vessels a rather large syringe may be used, provided with a point small enough to pass into the artery of the part to be injected. The artery should be carefully laid bare and cut about half way through; the point of the syringe, which must be previously filled with the injection mass, is pushed into the artery and firmly tied in place. In many cases it is quite sufficient to inject a cold saturated solution of Prussian blue in water, or when more perfect preparations are wanted, a little gelatine may be added; in this case, however, there arises the inconvenience that both the injection mass and the organ to be injected have to be kept warm while the operation is going on, otherwise the gelatine solidifies.

To prepare a "warm" injection mass, the following method is, perhaps, the best. A solution of Prussian blue is necessary; this the histologist must make for himself. To do this take a concentrated solution of sulphate of protoxide of iron in distilled water, and pour it slowly into a concentrated solution of yellow prussiate of potassium; a precipitate of insoluble Prussian blue is formed. There should be a small excess of prussiate at the end of the operation, to test which take out a drop and add to it a little of the sulphate. If there is any free prussiate still present, a blue precipitate is thrown down. Filter through a felt strainer, below which a funnel with a paper filter has been placed. Pour water on to the strainer in small quantities at a time, and continue filtering; this operation must be kept up for several days, until the liquid below the second filter appears distinctly blue. The matter on the felt strainer is then removed and dissolved in distilled water. This solution is admirable for cold injections or for filling the lymph-vessels, as will be described presently. There should always remain an excess of blue in the vessel in order to be sure that the solution is saturated; as the solution is removed it may be replaced by dis-

tilled water, as long as there is any blue left. To make the "warm" injection mass take twenty-five parts of the Prussian-blue solution and one part gelatine. The latter must be of the finest quality, as otherwise it produces a granular precipitate which renders it useless for histological purposes. Put the gelatine to soak for half an hour in distilled water, then remove and wash it; place it in a glass vessel and warm it in a water-bath, when it will melt in the water it has absorbed. The Prussian blue is put in another vessel in the same water-bath, so that the two liquids are at the same temperature. Pour the gelatine, little by little, into the blue, stirring constantly with a glass rod. Keep on warming and stirring until the granular precipitate formed at first disappears. Upon being filtered through a piece of clean flannel, the mass is ready for use.

It requires only to be slightly warmed to become liquid, and the organ to be injected does not need to be heated to so high a temperature as is necessary in using many other injection masses; there is, therefore, no danger of injuring the tissues by subjecting them to too high a temperature. The injection should be continued until a little while after the mass begins to come out through the veins, in order to allow all the capillaries time to fill themselves. When the injection is finished, the organ may be placed to advantage for twenty-four hours in a 2 to 1000 solution of bichromate of potassium in distilled water, and then be removed to alcohol; or it may be put at once in alcohol, and, when hardened, sections made of it. The sections should be pretty thick, and may or may not be stained as is desired. If too thin, they do not show the connections of the vessels.



(Fig. 76.) INJECTION OF HUMAN LIP.

As an example of the clearness with which the blood-vessels may be traced in a successful preparation, a figure of a section through an injected human lip is given (Figure 76). The shaded portion represents the skin proper, and is penetrated by papillæ sent up from the underlying connective tissue, known in anatomy as the cutis, and carrying the blood-vessels. There is a net-work of small arteries in the cutis, and from this there pass up from three to five fine branches into each papilla, and form by division and inter-communication a wide capillary net-work. One or several fine capillaries bend

round and form the veinlet which passes down the middle of the papilla, from top to bottom, in a nearly straight line, and sometimes taking up fine branches on the way until it finally connects with the venous net-work of the cutis.

This arrangement of the vessels is very characteristic; similar ones occur elsewhere, where there are well-developed papillæ, as, for instance, on the tongue or in the intestine. But each organ presents characteristic peculiarities in the distribution of its blood-vessels, and to an experienced histologist the veins, capillaries, and arteries of the liver and kidney, etc., are as distinctive of each organ as is its general shape and appearance.

As the presence of the valves does not permit us to inject the lymphatics from a large stem in the finer branches, as in the blood-vessels, a different method of forcing in the fluid has to be adopted. A small syringe with a very fine sharp point, such as is known among instrument-makers as a hypodermic syringe, must be used. The point is made to penetrate in the connective tissue, and the colored liquid — the best is a solution of Prussian blue — is forced out slowly and gently, and fills at first the cavities of the tissue and then the small lymphatics. These injections are difficult to make and by no means always succeed well. Perhaps the best place to try first is the interdigital web of the hind-foot of a frog, or the outer half, that is, the muscular part of the walls of the small intestine; but the easiest of all to fill are the lymphatics of the dog's testicles. When the injection has been once made in the way indicated, the tissue or organ may be hardened for cutting either in chromic acid or in alcohol.

Such, then, are some of the principal means employed to investigate the microscopical structure of animals. They all have this much in common, that they are endeavors to render certain characters more visible than they are naturally. This we do whether we stain the nucleus, or inject the blood-vessels, or isolate single cells. It may well be added that a good knowledge of optics is necessary to a good histologist.

The worker should also remember that American instruments are usually much less convenient and practical than the German and French microscopes, while the lenses are no better, though enormously more expensive. The writer personally likes Zeiss's instruments very much. As this optician manufactures his objectives upon mathematical principles, he is able to make them all nearly alike; but it must be understood that there are many others whose objectives are also of the best quality. At present

there is no difficulty in getting the best lenses and instruments, providing an American or English microscope of large size and complicated structure is not chosen. It will be found that those only who use a microscope for amusement utterly condemn the simple instruments, while those who make investigations and gather wide experience often assert that the greater the simplicity the better. The European histologists I have met generally use a stand without rack and pinion for coarse adjustment, without movable stage and without movement round a horizontal axis.

As to books, Frey's Manual, of which there has been a translation published in New York, is only pretty good. It came into general use because it was for a long time without rivals. There have lately appeared two little works on this subject, in England, one by Professor Rutherford, the other by Mr. Schaeffer, both of which are considered good. But by far the most important work is Ranvier's Traité Technique d'Histologie now being published in Paris, in numbers, three of which have already appeared. The moderate price of the book, — only twenty-five francs for a volume of a thousand pages, — the fullness of detail, and the superb illustrations alone are sufficient to recommend the work. M. Ranvier has written a treatise which will probably always be remembered as one of the most important and valuable manuals ever published, and which ought to be owned by every one who attempts to investigate the elementary structure of animals.

CONCERNING FOOT-PRINTS.

BY I. C. RUSSELL.

ICHNOLOGY (foot-print lore) is the name which has been applied to one of the most attractive and interesting paths of research that geology has pointed out. This branch of palæontology[1] has for its object the study and interpretation of the many fossil foot-prints that have been found in the rocks, which were impressed there by the feet of animals when the material of which those rocks are composed was the shifting sands along some ancient shore. The study of foot-prints has at length been recognized as a distinct and important branch of palæontology, one which has often afforded the only means for judging of the character and structure of the ancient animals that have left no other records of their existence than the impressions of their feet.

[1] From palaios, *ancient;* onta, *beings;* logos, *a discourse.*

The same principles of comparative anatomy that enabled Cuvier to reconstruct the skeletons of Tertiary mammals, a few bones of which were discovered near Paris, also give the ichnologist the power of calling again into being the forms of the animals which in times long passed impressed their foot-prints on the sand.

Let us see, first of all, how the records of these ancient foot-steps have been preserved for indefinite ages, so as to appear as fresh and well defined as if made but yesterday. It is evident that if a track is left in the loose dry sand, it is poorly defined and soon becomes obliterated; but if impressed on the wet sand at low tide, or on mud of the proper consistence, it may retain its form for a considerable time. The first and most common means by which such foot-prints are indefinitely preserved is by the rising tide filling and covering the impressions with the mud and sand borne on by the advancing waves. Each tide by depositing a sheet of sediment over the trodden surface would not only tend to bury the foot-prints deeper and deeper and thus secure their preservation, but the new deposit thus spread out by the waters might receive a series of records in its turn, made by the feet of the birds and reptiles that walked over it, and by the drops of rain that pattered down on the plastic surface, or by the retreating wavelets that rippled over the soft mud. Such inscriptions when once entered on the day-book of nature are imperishable until the rocky tablets that they form are again ground down to sand and dust in the great cycle of changes to which they are subjected.

Such preservation of foot-prints can nowhere be better seen than on the shores of the Bay of Fundy, where, owing to the great difference between high and low tide, — in some places amounting to seventy feet, — a broad extent of smooth, shining mud is left exposed at low water. Some portion of this soft surface is sure to be trodden by the numerous birds that feed along the shore, or to have its surface pitted by a passing shower; often, too, the mud is left in regular ripples by the retreating tide, and sometimes a leaf is borne out by the wind and dropped on the plastic surface, to record the character of the vegetation that fringes the shore. The red mud with all these inscriptions upon it is somewhat hardened by the warmth of the sun, so that it retains its place when the advancing tide rushes in. As the waters then sift down the fine mud which they hold in suspension, it fills each foot-print and rain-drop impression, and imprisons the leaves that are fast on the bottom; and thus is finished

another page in the records of the ages. When the tide steals slowly out, this deposit of silt is left behind with a smooth, glossy surface as before, ready to receive another series of impressions. This is not a rare or exceptional occurrence, but takes place nearly every summer's day on the shores of the great bay.

The constant accumulation of mud left in this manner by the retreating tides, although a single deposit may not exceed a sheet of paper in thickness, has yet formed thousands of acres of rich meadow-land, like the Tantramarsh and the broad meadows of Grand Pré, which retain, beneath their waving fields, the records made in the manner we have described, during hundreds and perhaps thousands of years before the Acadian farmers made that land their home. Sometimes upon splitting open the layers of hardened mud that form these meadows, the impressions made by the feet of animals are found; often, too, the bones of fishes are thus discovered, showing the manner in which the remains of the fishes that once swam in Devonian and Carboniferous seas have been preserved to our own day.

Another series of markings that are well displayed on the shores of the Bay of Fundy, and which are commonly associated with fossil foot-prints, are the shrinkage-cracks (or mud-cracks and sun-cracks, as they are often called) formed by the shrinking and cracking of the mud upon drying, when left exposed to the heat of the sun, — exactly as may be seen in every dried-up pool by the wayside. Such a net-work of intersecting fissures frequently covers many acres of the mud on the shores of the Bay of Fundy; and these modern mud-cracks often intersect and distort the foot-prints that have been previously formed, in precisely the same manner as the ancient foot-prints were sometimes distorted in the Triassic sandstone of the Connecticut valley.

The discovery of the stumps of pines and beeches rooted in what was once the surface of the soil, but now buried beneath the muddy deposits of the bay, prove, as pointed out by Professor Dawson, that the land has subsided and allowed the deposits to reach a greater thickness than they could otherwise have done. We can learn from this submerged forest a lesson that will be of value to us in all our geological rambles. It furnishes one of the many indications that the crust of our globe is not the *terra firma* it has been fancied to be, but is slowly rising in one place and sinking in another, and is sometimes pushed up into great folds from which mountains are formed. Recent research has shown that for hundreds of miles along the coast of Chili, the

land is slowly rising; a similar movement is taking place in Northern Europe; while, on the other hand, areas of equally great extent in some portions of the Indian and Pacific oceans are slowly sinking. That a gradual subsidence and an equally gradual deposition have together determined the mode in which great thicknesses of sediments have accumulated during many of the geological ages is clearly shown by the formations that contain from base to summit the indisputable evidences of shallow water origin.

The material that is continually deposited by the waters of the Bay of Fundy is furnished, for the most part, by the wearing away of the rocks along the shores of the bay. This process can nowhere be better seen than at the picturesque promontory at Hopewell, situated at the head of Shepody Bay. The Carboniferous conglomerate there forms a bold headland, which is being rapidly eaten away by the waves at high tide, so as to make one of the most interesting bits of coast scenery that we ever had the pleasure of seeing. The waves have not only worn the hard conglomerate into many dark caves and ragged capes, but have also cut out high archways, forming natural bridges that connect outstanding masses of rock with the shore. In some cases these bridges are wanting or have been washed away; and what were once bold headlands are now separated from the shore, but still bear on their summits a crown of trees and shrubs that were once continuous with the vegetation on the mainland. The masses of rock thus separated from the shore — frequently calling to mind the outstanding "buttes" along the Green River, and in other cañons of the far West — form islands at high tide, and are worn away at their base by the action of the waves, so that each is supported by a constantly diminishing column of stone, which at length gives way, and brings down the huge mass into the reach of the waves, which fast reduce it to sand and mud, to be spread out once more by the waters. The pebbles that compose the conglomerate, after being imprisoned in the rock for unknown ages, are again rolled up and down the beach as they were in the Carboniferous days when they received their form. We were interested to observe the ripple-marks on the coarse rocks, made when they were the loose sand and pebbles on the shore of the Carboniferous ocean, only a few inches from the similar forms impressed upon the soft mud by the retreat of the morning's tide. So exactly alike were the ripples in each case that a person could with difficulty appreciate the fact that one

series was formed millions of years before the other. The system of denudation and deposition so well illustrated at Hopewell Cape also furnishes a striking example of one of the most universal and far-reaching causes for the "imperfections of the geological record."

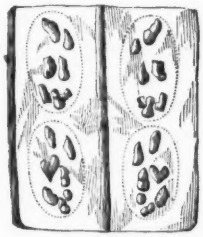
Another way in which foot-prints are preserved for long periods of time is by becoming filled with the fine sand and dust borne along by the wind, which by being drifted into the tracks penetrates their finest markings, and becoming covered with more blown sand, or by silt at high tide, retain, as already explained, an accurate mold and cast of the foot-prints, when the material shall have been hardened into rock. A counterpart of this second method of preservation can be seen when the newly fallen snow is drifted along by the wind and fills each cranny and crevice in the pavement; the snow gradually accumulates above, representing the sediment sifted down over the foot-prints on the shore, and sometimes becomes frozen into a solid mass, which when removed from the walks retains on its under surface an accurate cast of every line and crack on the stones beneath.

Still a third mode in which the impressions made by the feet of animals may be permanently preserved is seen when they are filled with fine sand and silt brought down by streams during sudden floods. The muddy waters then spread broadly out over the trodden sands, and cover them with a layer of fine mud; or, again, such a sheet of sediment may itself receive the impressions and be covered with sand by the incoming tide.

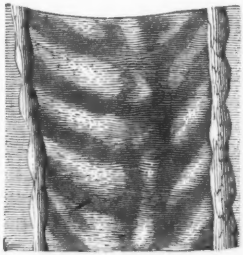
Layers of sand and clay when once deposited not only tend to become consolidated by the pressure of the mass that goes on forming above them, but are also penetrated by water bearing silica, lime, etc., in solution, which by being deposited around the particles of sand cement them together so as to form a compact sandstone; the strata of mud and clay may form at the same time beds of slade. Sandstones and shales being exposed to a high temperature or subjected to great pressure, are further metamorphosed and form quartzite and argillite, or the common slate used in the school-room. Throughout all these changes, however, the rocks sometimes retain the forms impressed upon them when they were soft sand and mud.

The oldest tracks known — excepting, perhaps, the trails left by annelid-like animals on the Taconic rocks of Vermont — were discovered some twenty-five years since in the Potsdam sandstone

at Beauharnois, Canada, situated about twenty miles westward of Montreal. These foot-prints were made a subject of study by Professor Owen, and were considered by him as having been formed by a large crustacean, resembling very closely in structure the *Limulus*, or "king-crab," so common along the Atlantic coast



(Fig. 77.) PROTICHNITES SEPTEMNOTATUS, O. Potsdam.



(Fig. 78.) CLIMACTICHNITES. Potsdam.

at the present day. The tracks consist of a medial furrow, accompanied on both sides by a large number of small indentations. The entire series of impressions is about six inches wide, and has been followed in some cases for several feet. It will be noticed that the tracks on each side of the medial line have a definite rotation and form separate groups which regularly succeed one another, — each of these sets of impressions in the trail represented above being formed by seven individual tracks on each side of the furrow. From the nature of the impressions and the regularity with which they succeed each other, we conclude that they were made by an animal having either seven individual legs on each side of the body, or else a fewer number of limbs which were divided at their extremities; the latter theory is the one that Professor Owen considered most probable. The modern Limulus, whose trail resembles these ancient foot-prints almost exactly, has five pairs of true legs, four of which are forked at their extremities, while the hindmost pair is terminated by four lamellar appendages. The rigid tail of the Limulus leaves a furrow on the sand over which the animal walks corresponding to the central furrow in the trails on the Potsdam sandstone. That this ancient furrow was also made by a rigid tail, and not by the under surface of the animal's body, is shown by the fact that when a sharp curve was followed, the medial furrow swept to one side and sometimes obliterated the foot-prints on the convex side of the trail.

Several series of foot-prints of the same general nature as

those shown in Figure 77 have been discovered at Beauharnois and at other localities in Canada; to all of these the generic name of *Protichnites* (*earliest foot-prints*) has been given. These trails differ among themselves, however, principally in regard to the number of individual tracks in the successive series of impressions. Some of the trails have seven separate indentations in each corresponding series, and are hence designated as *Protichnites septem-notatus;* others with eight impressions in each group, making sixteen as formed by all of the feet of the animal at the same time, are known as *P. octo-notatus;* others have received the name of *P. multi-notatus.* When we remember the great antiquity of these foot-prints, their discovery is seen to be of peculiar interest. The Potsdam sandstone on which they were impressed forms the base of the Silurian system in this country, and is almost the oldest formation in which well-defined fossils have been found. If we attempt to enumerate the centuries that have passed away since these delicate foot-prints were traced upon the sandy shore of the old Silurian ocean, we find ourselves as totally bewildered by the almost infinite lapse of time as we are when we endeavor to comprehend the distance of the fixed stars in space.

Splendid specimens of *Protichnites* can be seen at Montreal, in the rooms of the Geological Survey of Canada, to whose former director, Sir William Logan, we owe our knowledge of these interesting fossils. No one can examine those slabs of sandstone, with the strange trails sweeping across them, without some of that feeling of mingled wonder and awe which creeps over us when we see the inscriptions of some ancient people regarding whom tradition is silent.

These trails are not only interesting from their great antiquity, but also because they afford the only records ever discovered of the animals that made them. We find in the rocks that have afforded these foot-prints a few fossil sea-weeds, which mark the humble commencement of the flora of the globe, the shells of the Lingula, which are quite abundant at some localities and are the most common fossils from this formation, and also a few shells of other brachiopods, and some equally rare specimens of gasteropod shells. These lowly forms of life, together with a few species of trilobites, some of which, however, reached a very large size, make up the scanty fauna of those early days. None of the animals in this brief list could have left trails on the sand at all similar to those known as *Protichnites*, which owe their im-

pression to some unknown crustacean of a higher degree of organization than any of the animals we have enumerated, which was literally the king-crab along the shores where it made its home.

The Potsdam sandstone has also yielded another series of foot-prints fully as large as *Protichnites*, called *Climactichnites*, in reference to their striking resemblance to a rope-ladder. These impressions (Figure 78) consist of two furrows, about six inches apart, the interspace crossed by parallel curved furrows that represent the rounds of the rope-ladder; there are also indications of a medial furrow, as in *Protichnites*. Of the animal that formed these trails even less is known, as can be inferred, than of those whose tracks we have been considering. They are supposed by some persons to be the track left by a huge trilobite, like *Paradoxides Harlani;* others consider them as the trail of a large gasteropod, no other records of which are known. Although the trail known as *Climactichnites* differs greatly in appearance from *Protichnites*, yet it is not impossible that they were formed by the same animal under different conditions: one impressed upon the sands while walking, the other, perhaps, formed by the swimming appendages, which are supposed to have resembled those of the Limulus.

As we have seen, the crustaceans were the highest forms of life in the Silurian oceans; their reign was terminated, however, about the close of the upper Silurian, by the introduction of fishes, which continued to be the rulers of the ocean throughout the Devonian age, which, for this reason, is often spoken of as the age of fishes. Another great advance was made in the life of the globe during the Carboniferous age, when the air-breathing reptiles first came upon the stage of being. The existence of these more highly organized animals in the Carboniferous age was first made known by the discovery of their foot-prints. The honor of first bringing these interesting relics to the notice of geologists is due also to Sir William Logan, who discovered reptilian foot-prints on slabs of Carboniferous sandstone in 1841, at Horton Bluff, Nova Scotia. Shortly afterwards, the well-known discovery of the foot-prints of a large amphibian, named *Sauropus primævus*, was made at Pottsville, Pa. For some time the foot prints of these ancient reptiles were the only evidence known of their existence. These scanty records, however, were enough to demonstrate that lizard-like reptiles, of considerable size and of a high organization, existed during the age in which the coal deposits of Nova Scotia and Pennsylvania were formed.

After a time the skeletons of some of the Carboniferous reptiles were brought to light. One of the earliest and most interesting of these discoveries was made by Lyell and Dawson, while examining the stump of a Sigillaria, one of the most common trees of the coal swamps, which had been buried in the sand that now forms the thick beds of sandstone at the South Joggins, Nova Scotia. The stump in question seems to have rotted away in the interior during the time when it was partially buried in the sand, so as to form a convenient retreat for the reptiles that made it their home, and in which they died as they were entrapped by the sand, which at length filled the stump and preserved the remains. Other skeletons of Carboniferous reptiles have since been discovered in considerable abundance at Linton, Ohio. A careful study of these remains has shown that there was no lack of diversity or of ornamentation and beauty among the reptiles that recorded their existence on the sands of the Carboniferous sea-shore, the authenticity of which has been so abundantly verified.

(Fig. 79.) SLAB OF TRIASSIC SANDSTONE WITH TRACKS OF BIRDS AND REPTILES.

In the Triassic period, which next succeeds the Carboniferous age in geological history, another great advance was made in the progress of life on the earth by the appearance of birds, which, as a class, stand next above the reptiles in the zoölogical scale. The existence of the feathered tribes during the Triassic period was first made known by the discovery of their foot-prints in the red sandstone of the Connecticut valley.

The Triassic formation in which these impressions were found fills the greater part of the Connecticut valley, and is again largely developed in New Jersey, affording in that State the red shales and sandstones so well known to travelers over the various railroads that radiate from Jersey City. It is this formation that furnishes the "brown stone" so largely used for architectural purposes in New York and the neighboring cities. The same formation stretches southward as far as Virginia and North Carolina, where it contains highly valuable beds of coal.

The foot-prints found so abundantly in the Connecticut valley frequently seem to have been impressed upon a layer of soft mud, now shale, and to have been covered with a layer of sand, now hardened into a firm sandstone, which, upon being raised from its native bed, retains upon its under surface, standing out in relief, an exact cast of the foot-prints. These natural casts are often as perfect as if molded in plaster, and sometimes retain even the lines and creases of the skin which covered the feet of the animals that impressed them. These tracks have not been found in a few rare instances, but number many thousands, obtained from nearly forty localities in the valley of the Connecticut; the writer has also obtained several species from Pompton and Plainfield, N. J.

We commonly hear these fossil foot-prints spoken of as "bird tracks;" they include, however, very many that are clearly reptilian in their character. Others have been referred to marsupial animals by Professor Hitchcock, to whose splendid report on the Ichnology of Massachusetts we would refer our readers for detailed and accurate information on this subject.

No skeletons of these ancient inhabitants of Connecticut and New Jersey have been found sufficiently well preserved to substantiate the conclusion of geologists that many of the tracks were made by birds, as the class is at present defined. Some persons are inclined to ascribe the bird tracks to kangaroo-like reptiles, which walked on two legs, like the gigantic *Hadrosaurus* that inhabited the shores of New Jersey in the next succeeding age, — the Cretaceous. Some fortunate discovery of the skeletons of these animals will possibly show that they possessed something of that strange "synthetic structure" so often met with in geological history. It is not improbable that these earliest of birds possessed a combination of reptilian and avian characters, exemplified by the *Archæopteryx*,[1] the *Pterodactyls*,[2] and the toothed birds from the Cretaceous formations of Nebraska.

The principal reasons that have led geologists to consider many of the Connecticut foot-prints as having been made by birds are that the animals were clearly bipeds, and left a tridactylous, or three-toed, impression on the mud; some of them had a fourth

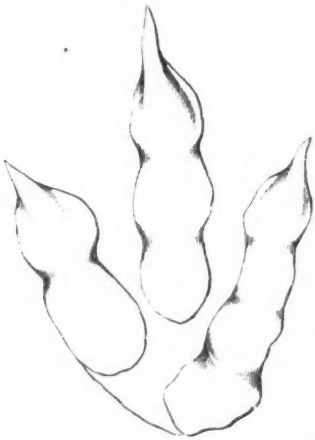
[1] A fossil bird found at Solenhofen, Bavaria, having short, rounded wings with claws attached, and a long lizard-like tail, composed of about twenty vertebræ, each supporting a pair of quill-feathers.

[2] A genus of flying reptiles belonging to the Jurassic and Cretaceous ages, which possessed membraneous, bat-like wings, that sometimes measured twenty-five feet from tip to tip.

toe, connected with the metatarsal bone above the foot (as in many modern birds), which sometimes left a slight impression on the trodden surface. But the most striking analogy between the ancient tracks and the foot-prints of modern birds is to be seen in the fact that the phalanges, or joints of the toes, have the same numerical ratio in each; that is, in three-toed birds the inner toe has three, the middle one four, and the outermost one five phalanges.

The force of these arguments in favor of the ornithic character of the foot-prints has been somewhat impaired by the discovery of tracks bearing these peculiarities, but having, also, in connection with the large tridactylous impressions of the hind feet the much smaller five-toed tracks formed by the fore feet of the same animal, showing that they were made by a reptile. Sometimes a medial furrow accompanies such tracks, indicating that the animal possessed a long, strong tail. These discoveries, although proving that there have been three-toed reptiles, yet by no means prove that all the "bird tracks" were formed by such animals.

We learn from the Triassic foot-prints that the strange creatures that impressed them not only inhabited the Eastern States in great numbers, but also that there was great variety in that ancient fauna.



(Fig. 80.) BRONTOZOUM GIGANTEUM
Triassic.

The accompanying figure of the foot-print known as *Brontozoum giganteum*, from Professor Hitchcock's report, represents the largest of the bird-like tracks found in the Connecticut valley. The foot-print represented in the figure as two and one half inches in length is in fact eighteen inches long and a foot in breadth, indicating, not only from the size of the foot-print, but from the manner in which the trodden surface was crushed down, and also by the length of the stride that separates the steps, a bird of gigantic proportions, that must have far surpassed in size the largest of living birds, — although probably not exceeding the dimensions of the *Dinornis giganteus*, which at no very distant time inhabited New Zealand.

"The giant ruler of the valley," however, was the great *Otozoum*, a huge biped reptile, whose foot-prints were each twenty inches in length by sixteen inches in breadth, and separated by strides three feet long; its great weight pressed down the sands as if an elephant had walked over them. Together with these gigantic foot-prints are found the tracks of other and much smaller denizens of the shore. The smallest of the Triassic reptiles, as indicated by its track, could not have exceeded a common frog in size. Associated with these are found the trails of worms and curious markings supposed to have been made by the fins of fishes, which we know inhabited the waters in great numbers.

The smooth, glossy surfaces of the slabs bearing the foot-prints have often received other inscriptions which are scarcely less interesting than the records of animal life. Frequently the surface of the rock is pitted with impressions made by falling rain-drops, and we can even tell the direction from which the wind blew during the time that those ancient showers watered the earth. The ripple-marks plainly tell that the soft mud was covered with water, which then, as now, broke in ripples on the beach. The sun-cracks no less clearly prove that the wet mud was left exposed to the heat of the sun, which caused it to shrink and crack, and that the surface was again covered with water which filled the cracks with sand and thus secured their preservation. These combined records show that the tide ebbed and flowed along those ancient shores, and that when it was at its lowest, it left exposed a broad stretch of shining mud, like that which borders the Bay of Fundy at low tide; upon this plastic surface the strange, uncouth monsters that emerged from the deep impressed the imperishable records of their existence.

We will leave to our readers the pleasure of picturing the strange scenes that filled the valley of the Connecticut in those distant days, when conifers, cycads, and ferns of tropical growth formed a varied and beautiful border to the valley and furnished shelter and food for the singular creatures whose footsteps we have followed.

To those who would drink deeper of this "foot-print lore," we recommend the writings of Hitchcock, Deane, Lea, Owen, etc.; or, still better than all, to pry open the leaves of the ancient tile library of nature, and interpret for themselves the cuniform impressions with which they are inscribed.

EXPERIMENTS ON THE SENSE-ORGANS OF INSECTS.

BY A. S. PACKARD, JR.

THE interesting experiments of Mr. Trouvelot, described in the April NATURALIST, which it should here be explained were in my hands eight years before their final publication, the MS. having been overlooked, led me to make similar experiments, which are offered here with the hope of stimulating some more competent observer to work up the subject in a more complete and scientific way.

From a worker honey bee (*Apis mellifica*) I removed one antenna. It flew with difficulty and acted as if much hurt. On removing the other, except the first and second joints of both antennæ, it appeared to be semi-paralyzed, and on being tossed up in the air fell helpless to the floor, and did not at first walk about much, but in two or three minutes recovered sufficiently from the shock of the amputation to walk, though it had apparently lost the power of coördination and also the power of stinging; but it soon recovered its strength enough to fly a little, and began to dart out its sting, but most of the time it buzzed about on the table on its back. After four or five minutes it came to, and flew with a comparatively steady flight to the window on being thrown up in the air. It then walked up the window-pane.

On removing the stumps of both antennæ it was partially paralyzed, and dropped repeatedly on the floor upon being thrown up in the air. It did not regain its wits as soon as before, but remained on the window-sill walking about, not climbing up the pane. It, however, had the power of partially coördinating its steps, and would now and then clean its feelers (palpi) by drawing them through its jaws. It would not sting me even on pressure with the finger. Fifteen minutes afterwards it had not recovered the power of flying, and in essaying flight would fall on its side, buzz about on its back, and then walk staggering along. The movements of the mouth-parts were not affected. One hour after deantennization it would remain motionless, and on violently tapping the window-sill on which it rested it would not stir, but on touching it slightly it moved a little, and soon became motionless; after this a still heavier tap would slightly startle it. Upon depositing a drop of dissolved sugar within a line of its head it did not notice it; on daubing it over the end of the

stump of the antennæ no movement was made by the bee, but as soon as the fluid had spread and moistened the mouth-parts it unbent its maxillæ and vigorously lapped it up, the tongue (lingua) playing back and forth between the maxillæ as the latter spread open a little. During this operation I held the bee between my fingers; it did not sting me, but soon thrust the sting partly into the skin of my finger, showing that the power of stinging had partially returned.

This experiment seems to show that the sense of hearing may reside in the antennæ of the honey bee, while that of smell has its seat in the palpi (and perhaps the tongue) alone. It would also seem as if the antennal nerves were so continuous with the supraœsophageal ganglia that they are as it were part of the brain, their removal at a little distance from their origin producing such a shock to the ganglionic nervous system that the insect acts somewhat like a bird on being deprived of the cerebral hemispheres, while the special senses in the organs left untouched are not affected. The bee was more profoundly impressed by the mutilation than other insects, as will be seen by the following experiments, and this is evidence in favor of the view that the Hymenoptera and the honey bees especially, stand at the head of the insect creation.

On removing the antennæ from a species of *Andrena*, a common wild bee, it immediately fell on its back as if stunned, and lay on its side curled up as though hurt, and on letting it fall would drop down and lie still on the table, not trying to use its wings. It laid several hours on its back and then died. On the other hand a smaller species, about half the size of the other, on being treated in the same manner did not seem to be much affected, as it walked about in its usual lively fashion on the table and finally flew out of doors. A small *Halictus* and *Augochlora* bee, after the loss of their antennæ, flew with a little less directness and freedom, but showed no signs of being hurt. A humble bee (*Bombus Virginica*) and wasp (*Vespa maculata*) on being deantennized acted in much the same manner; on being thrown up in the air they would repeatedly fly to the window, not being stunned as in the honey bee, though they were somewhat affected, occasionally falling over on to their backs and remaining there several minutes. A second wasp of the same species acted in the same manner after the same style of treatment. On placing dissolved sugar on the stumps of both antennæ, no impression was made upon it, though when put to its

mouth it eagerly lapped the sweet. Finally the wasp flew out of the window.

I removed the palpi or feelers from a female *Polistes* wasp, leaving the stumps of the maxillary palpi. It did not eat the sugar with its usual heartiness, but still extended its tongue slightly. One experiment like this proves nothing, but suggests that the sense of smell or taste probably resides in the tongue and base of the maxillæ of these insects as well as in the palpi.

A female blue mud dauber (*Pelopæus cæruleus*) on removal of the antennæ showed no less activity than before and flew and ran about in its ordinary manner.

A large blue-black ichneumon-fly on removal of the antennæ was not affected much. On placing a lump of sugar at its mouth it eagerly lapped it, but on removing both pairs of palpi, leaving short stumps, it did not lap the sugar, though I repeatedly put it close to its tongue and actually plastered the solution on the tongue. I also put the insect into a cup with a solid mass of sugar at the bottom, but it did not eat it, having apparently entirely lost the sense of taste. In this insect it would seem as if the sense of taste resided in the ends of the palpi. Previous to their excision they moved very briskly while the ichneumon was lapping the sugar with its tongue.

In walking up the side of the glass as well as on the table it felt its way in a peculiar tentative manner with its left fore leg, the short stumps of its antennæ all the while moving, showing that the antennæ rather than the eyes are used in walking, and that when deprived of its antennæ and eyes it uses one leg like a blind man his stick to feel its way.

An ichneumon of another species on removal of its antennæ and of the labial and the terminal half of the maxillary palpi, lapped sweetened water.

A small *Microgaster*, on partial removal of the palpi, leaving only the stumps, acted like the larger ichneumons.

A small brown ant on losing its antennæ was at first evidently much shocked, turning round and round in a confused manner, but in a minute or two it walked off nearly as well as ever. It found its way to the rim of a goblet and lapped the sugar solution with its tongue, the maxillary palpi being extended straight backwards. It cleaned its fore legs, drawing them through the maxillæ.

A number of butterflies and moths were experimented upon. On removal of its antennæ a *Papilio Asterias* flew irregularly to

the floor, remaining there; on opening the window it flew out heavily, having evidently lost some of its powers of flight and of directing the movements of its wings. It remained just where it had settled in the path from four P. M. until after nine o'clock the next morning. Then on putting it in a sunny place it disappeared five minutes after, and must have become warmed and flown away.

A *Colias Philodice* on removal of its antennæ did not fly quite so readily as one in the same room unmutilated, but the difference was not marked; two deantennized *Pieris rapæ* behaved in the same manner as the *Colias*.

An *Argynnis Idalia* in losing its antennæ seemed but slightly affected, but showed more of a tendency to drop to the floor than if in a natural condition. On putting sweetened water on the ends of the stumps of the antennæ, in a minute it partly but not wholly unrolled its maxillæ. On moistening the ends of the labial palpi no effect was produced; on moistening the base and ends of the maxillæ they at once unrolled and felt about for the sweet object with their tips, and on putting a drop of sweetened water on the window frame in front of it, it eagerly lapped it with the maxillæ, and on losing the place of the drop it felt around until it found it and then again lapped it. This experiment tends to show that both the sense of taste and touch must reside in the maxillæ of the Lepidoptera, and not in the palpi.

On removing the antennæ of a *Deilephila lineata* which had just come from the chrysalis, it seemed to fly more vigorously than before, and to be rendered more restless in its motions. On snipping off the antennæ of an *Agrotis subgothica* which came in at a lighted window, it tumbled about headlong at times, being evidently top-heavy and confused. Another owlet moth, *Drasteria erechtea*, on losing its antennæ did not seem to suffer, and soon recovered sufficiently to fly out of the window upon the grass and to start up in its usual manner and fly off at my approach. A *Crambus* similarly treated acted in a similar manner.

The sense of touch in the Lepidoptera does not evidently reside in the antennæ alone, and all the experiments show that after the loss of the antennæ if disturbed, jarred, or touched, they are still sensitive and fly off.

A few flies were experimented upon, the antennæ being snipped off. A *Chironomus* was much affected; it flew about wildly bouncing on its head, and did not fly up the window-pane upon partial recovery. On the other hand no effect was pro-

duced on a *Tipula* or daddy-long-legs. A large blue-bottle fly (*Musca Cæsar*) seemed to suffer no ill effects, and it was found flying on the window the next day, lively and apparently unconscious of its loss.

Three *Stomoxys calcitrans* on losing their antennæ seemed not at all affected, being as lively as ever, wiping their feet and running and flying up the window, with motions identical with others of their species on the same window.

On removing the antennæ from a beetle (*Harpalus caliginosus*) no difference in its motions was observed; a *Clytus robiniæ* seemed, however, slightly discommoded, while an *Ellychnia corusca*, when mutilated, walked slowly and with difficulty, where before it walked with moderate rapidity touching the ground incessantly with its antennæ; it did not move in a direct line, but hesitatingly, and sometimes tumbling over on one side. It was evidently gravely affected, and finally remained quiet for several hours; a potato beetle (*Leptinotarsa decem-lineata*) acted in the same manner. On the other hand a weevil, *Hylobius pales*, on losing its antennæ, exhibited no signs of discomfort; it did not feign death at first, nor did it walk over the table with a less well directed gait than before.

A few Hemiptera, which, it should be observed, have no palpi, suffered the loss of their antennæ. *Cicada canicularis* flew about more lively than before it was operated upon. In *Coreus tristis* no effect was produced, while a large *Arma*-like bug was made more sluggish.

The red-legged grasshopper (*Caloptenus femur-rubrum*) was not affected, nor was *Orchelimum agile*, while a cricket (*Nemobius vittatus*) on losing its antennæ, at once stopped, not leaping more than two inches, and walked slowly, but used its palpi in walking, cleaning its legs with them. On removing the labial palpi its movements were not different, though, if anything, livelier. On removing the maxillary palpi, no difference in its actions was produced. A common *Gryllus*, in losing its antennæ, was but slightly affected.

A large dragon-fly, *Æschna heros*, on the loss of its antennæ, seemed to fly freely about the room, but would butt against the wall, and on being taken out of doors, flew to the ground, where it usually flies rapidly off in the air.

Spiders seemed to be affected by the loss of their maxillary palpi much as insects by the loss of their antennæ. A female *Lycosa*-like spider, after the removal of its palpi, for four or five

minutes moved slowly, but with a direct, well coördinated gait, then it partly recovered, and moved more briskly. Another smaller *Epeira*-like spider did not seem to suffer, except that its motions were slower, and on being touched, it would gather up its legs and feign death.

A species of *Julus* and of *Polydesmus*, on amputation of their antennæ, rather long stumps remaining, were at first somewhat discommoded and then seemed to walk well, but less rapidly than before.

It would be premature to draw any inferences from these experiments, but the impression is left on the mind that in removing the antennæ in some cases, it seemed as if something more was effected than making the insect deaf or depriving it of the sense of taste or smell, and it seemed as if the ganglionic centres were affected, particularly the supra-œsophageal pair, the insect being at first more or less stunned or confused, and then, in many cases, acting as if the nervous centres were permanently affected; not so much as if one of its senses, but all or nearly all, were more or less affected. In fact, the movements somewhat resembled those of a dove from which the cerebral hemispheres had been removed, as in the case described in Dalton's Physiology, and the fact that the insects can distinguish light from darkness, perhaps the main function of the eyes, and taste their appropriate food, does not militate against the idea that the nervous centres are seriously affected. On the other hand, no such effects are produced when the leg, or even, in some cases, the abdomen, is removed. I do not see that my experiments enable us to prove anything as to the nature of the function of the antennæ, except to indicate that the insect's brain is as it were projected into them, and that their nerves probably possess nucleated cells, homologous with those of the ganglia from which the sense-nerves originate.

RECENT LITERATURE.

Ganin's Metamorphoses of Insects.[1] — The author begins with a rapid survey of previous investigations by Weismann, Uljanin, Chun, Paul Mayer, Auerbach, and shows the unsatisfactory condition of our knowledge and the necessity of a verification of the statements of those

[1] *Materials for a Knowledge of the Post-Embryonal Development of Insects.* By Professor M. Ganin. Warsaw. 1876. 4to, 76 pages and 4 plates. (Extracted from the Transactions of the Fifth Meeting of Russian Naturalists in Warsaw; Section of Zoölogy and Comparative Anatomy.)

authors. "My own observations," says he, "embrace several Diptera (*Anthomyia, Sarcophaga, Musca domestica, Scatophaga, Eristalis, Stratiomyia*); several species of *Formica* and *Myrmica*; one Lepidopteron, *Lithocolletis*; and of Coleoptera, *Tenebrio* and *Chrysomela*. Among the Diptera, my fullest researches were those on *Anthomyia rufipes*, a smaller species being easier to handle in preparing cross-sections, especially in the pupa state, when most of the organs are destroyed. In *Sarcophaga carnaria*, I observed the structure and the development of imaginal discs, anterior to pupation. The relationship of this species, as well as of *Musca vomitoria*, studied by Weismann, to *Anthomyia* authorizes the assumption that whatever is explained here about the development of the latter genus is equally applicable to *Musca vomitoria* and *Sarcophaga carnaria*, and also to the other above-named *Muscidæ*."

"More or less complete are my observations on the development of the teguments of the head, the thorax, and the abdomen, with their excrescences; also on the development of the alimentary canal. The aim of my studies was not so much to investigate the details of the development of this or that organ as to observe the mode of formation of the rudiments of organs, the material out of which they are developed, and the time of their appearance. Many facts, introduced into science by Weismann, — for instance, those which refer to the part played by the imaginal discs in the development of the imago, — must retain their scientific weight, with slight emendations, with respect to the development and structure of those discs; but another category of results, elicited by Weismann, — namely, those relating to the histolytic processes, the formation of the tissues of the imago from the produce of the destruction of the organs of the larva, — must be considered as erroneous and replaced by others." (Pages 4, 5.)

The main portion of the author's dissertation is divided into nine chapters, which embody his own observations, and are entitled, *Imaginal discs* (Muscidæ); *History of the development of the head; History of the development of the abdomen of the imago; Adipose body and destructive processes; Imaginal discs of the ant* (Myrmica); *History of the development of the leg of Lepidoptera and Coleoptera; History of the development of the alimentary canal* (Muscidæ); *History of the development of the proboscis; History of the development of the alimentary canal of Myrmica, Lithocolletis, and Tenebrio.*

It would be impossible fairly to render the contents of these chapters without translating the whole of them; it will suffice here to give a translation of the concluding chapter (page 64), which sums up the author's results and views. "*Conclusions.* In consequence of the above-stated facts, as well as of several still unfinished researches of mine concerning the development of the central nervous system and of the dorsal vessel, we may reach the conclusion that the formation of the organism of the imago, during the period of its post-embryonal development, is

accompanied by the following processes : *Processes of destruction*, when organs or tissues of the larva are entirely or partially disintegrated. The products of this disintegration are not used immediately in the development of new histological elements, but are assimilated by suction and play the part of nutritive materials. *Processes of transformation*, I call those morphological processes, during which the formation of a new organ takes place without the participation of a newly formed morphological rudiment, but when the old organ, without being destroyed, passes into the morphologically corresponding organ of the imago, the newly appearing organ differing more or less, morphologically and histologically, from the old one. Thus the central nervous system of the larvæ of *Muscidæ* is not destroyed, but is transformed into the central nervous system of the imago, the latter differing very much, in its shape and structure, from the former: new parts have appeared; the first knot of the abdominal cord, not existing in the larva, is differentiated; the *ganglion opticum* is newly formed; the shape and structure of the abdominal cord are changed, etc. The histological elements of the tissues of the new organ are derived from those of the transforming larval organ. It is very probable that the dorsal vessel of the imago of *Muscidæ* is only transformed from the dorsal vessel of the larva. It seems to me that in the *Muscidæ* the dorsal vessel does not interrupt its functions during the period of post-embryonal development: very often the contractions of the dorsal vessel of *Anthomyia rufipes* were observed during the second and third day after pupation, when the greater part of the larval organs were already destroyed. The trifling differences between the dorsal vessel of the imago, as compared to that of the larva, may consist in its shape, the number, shape, and position of its wing-shaped muscles, the number and position of the venose openings, etc.

"*Processes of the formation of new organs.* The variety of these processes depends, of course, on the morphological and physiological conditions of the newly forming organ. These processes consist in the building up of an organ of the imago from a special morphological rudiment. Thus from the morphological rudiments called imaginal discs, are evolved entirely new parts of the body of the imago, with their different tissues — head, thorax with the extremities, muscles, nerves, etc.; portions of the cephalic discs are converted into the compound eyes of the imago; out of the thickening of the abdominal segments of the larva of *Anthomyia* is developed the musculature of the abdominal segments of the imago, etc. It must, however, be at the same time remembered that there are no well-marked boundaries between these different processes; the terms used are intended merely to designate the most marked phase of this or that process. The definitions given of those processes have only a relative meaning, like all our definitions in morphological science.

"Finally, it also happens that parts or organs of the larva, during the period of the post-embryonal development, will pass into the corresponding parts of the imago without any change, or with very little change. Thus, for instance, a part of the adipose body of the larvæ of the *Muscidæ* and of the ant pass into the adipose cells of the imago. It is worthy of notice that it is only after the last molt of the larva of *Corethra* that those large bundles of colossal adipose cells make their appearance, which surround the anterior tracheal bladders; but they pass without any change into the imago, without furnishing, directly or indirectly, any material for the formation of the organs of the imago. This fact, taken singly, does not weigh in favor of the importance of the adipose body as a living, plastic material for building up the organs of the imago in the period of the post-embryonal development. The so-called histolytic processes, in the sense of Weismann,[1] as well as the process of an independent formation of the cells from the products of the destruction of the larval organs, I have never observed.

"The comparative examination of all these processes, which take place in the period of the post-embryonal development of different insects, leads us to the conclusion that, from the number of the processes of new formation and destruction, as well as from their morphological meaning, the highest place in the series of all the insects must be granted to the *Muscidæ*. Besides the already known facts of comparative anatomy, may be adduced the data obtained through embryological researches, which confirm the above-mentioned statement. The position of the imaginal discs in the cavity of the body, the mode of development of the head, the chest, the proboscis with all its parts, the entire destruction of the exoderm of the first four segments of the larva, the entire destruction of all its abdominal muscles, etc., — all these circumstances lead to the conclusion that the organism of the *Muscidæ* has undergone more modification than that of any other insect, during its phylogenetic development. The mode of development of the strata of rudiments in the imaginal discs of the *Muscidæ*, as compared to that in the discs of other insects, serves to confirm that conclusion. In the larvæ of *Muscidæ*, both strata of rudiments of the disc are formed anew from a common cellulose germ on the peritoneal envelope of the tracheal tube, or on the neurilemma of the nerve. In *Corethra*, *Miastor*, and in the Hymenoptera, strictly speaking, the mesoderm of the disc is alone a new formation, developed with the participation of the nerve and the tracheal tube; the exoderm of the disc is derived from the epithelial

[1] I say in the sense of Weismann because later observers, as C. Chun, P. Mayer, often use the term *histolyse* indifferently: often cases of ordinary destructive processes are called by them *histolyse*. Weismann, on the contrary, clearly distinguishes this second *histolytic* process from the three other processes of formation of the organs of the imago. The *histolyse*, according to Weismann, takes place only when the organ of the larva furnishes the skeleton to the organ of the imago, etc., etc.

cells of the thoracic segments of the larva. In butterflies and beetles, the part corresponding to the exoderm of the imaginal disc is derived from the epithelial sac of the leg of the larva; the mesoderm likewise is a new formation. It is very probable that a further inquiry into the processes of the post-embryonal development of other Diptera, and also of insects of other orders, principally of such groups as have so-called apodal larvæ, will disclose some transitional forms of post-embryonal processes leading towards the extreme and well-characterized type of development of the *Muscidæ*. Thus it is now well known that *Miastor*[1] is a connecting link between *Muscidæ* and *Tipulidæ*, as regards the history of the development of its head. The dorsal portion of the head of *Miastor* is developed from the cephalic discs, the position of which is similar to that of the cephalic discs of the *Muscidæ;* the ventral and lateral portions of the head of the imago of *Miastor* are developed with the participation of the teguments of the larval cephalic segment. The development of the organs of the mouth of *Miastor* is much nearer to that of *Corethra*.

"The musculature of the head of the larva of *Miastor*, according to Zalensky, passes without change into the muscles of the head of the imago. It is to be regretted that we do not find in the work of Zalensky any mention of destructive processes in the cephalic segment of the larva of *Miastor*. If the destruction of the exoderm of the cephalic segment of the larva is not recognized, at least in its dorsal region, it is difficult to understand how the newly formed part of the head can assume its normal relative position towards the old larval exoderm of the cephalic segment.

"Some morphological importance must also be attributed to the interesting fact, that in the larva of *Miastor*, the formation which is homologous to the pair of cephalic discs of the larvæ of *Muscidæ* appears in the shape of a single (not paired) organ, although judging by the nerves with which it is connected, it corresponds to the pair of cephalic discs of the *Muscidæ*.

"The principle adopted by Weismann for the division of all insects into two sharply defined types, according to their post-embryonal development, and which depends upon the presence or absence of histolytic processes, and also on the mode of formation of the histological elements of the tissues of the imago, — in one case from the *Körnchenkugeln*, in the other with the participation of the elements of the tissues of the larva, — after all that has been said above, must lose its scientific value. It seems to me that the principles which must guide us in the grouping of insects with regard to their post-embryonal development are the number and quality of the destructive processes, the different modes of the building up of the organs of the imago from the newly

[1] Article by Mr. Zalensky, in the Proceedings of the Third Meeting of the Russian Naturalists in Kiew.

formed morphological rudiments, the number and the morphological importance of the organs transformed from the organs of the larva, and of those which pass, without change, into the organs of the imago.

"I deem it proper to examine here the question of the morphological importance of the imaginal discs of insects in general. The data respecting their embryology and comparative anatomy render it very probable that the thoracic imaginal discs, hidden in the body of *Muscidæ*, the thoracic imaginal discs placed immediately on the skin of *Corethra*, *Miastor*, and the Hymenoptera, and the thoracic legs of the larvæ of Lepidoptera and Coleoptera, are homological formations, replacing each other in all those groups. In other words, and more explicitly, I believe that the thoracic imaginal discs of the Hymenoptera, *Muscidæ*, *Corethra*, and *Miastor* are nothing but reduced ambulatory legs, which in other insects (Lepidoptera and beetles) are used as organs of progression, but in the above-mentioned groups (*Muscidæ*, etc.), have lost their physiological value, and have preserved in the history of their development a mere record of that value. This view may be sustained by the following scientifically pregnant facts: (1.) All insects, the larvæ of which possess, in their thoracic segments, the so-called imaginal discs, do not have any rudiments of legs on the same segments during the period of their embryonal development; in other words, the imaginal discs take the place of the legs, which, in other insects, appear much earlier, in the same places, during the period of the embryonal development. (2.) In insects, the larvæ of which possess thoracic legs, these latter are transformed into the legs of the imago, in such a manner that the final segmentation of the joints of the leg of the imago appears more or less sudden and simultaneous, in consequence of the segmentation of the corresponding leg of the larva, which has been very much drawn out in length. On the contrary, those insects, the larvæ of which, instead of thoracic, ambulatory legs, have imaginal discs, show, before the appearance of the final segmentation of the leg of the imago, a stage of a *provisional* segmentation of the leg in the developing imago. Thus, the segments of the leg of the imago of *Muscidæ*, Hymenoptera, etc., do not all appear simultaneously, but gradually, first one, then two, three, etc. This provisional segmentation of the leg, growing out of the imaginal disc, must be considered, probably, as the expression of the ultimate segmentation of the leg which it formerly possessed; or, in other words, the provisional segments of the leg, developing from the imaginal disc, remind us of the permanent segments of the larval legs of Lepidoptera, beetles, etc., which, in these latter, are used as temporary, provisional, locomotive organs. (3.) I believe that great morphological importance must be attached to the fact that during the development of the imaginal disc of the *Muscidæ*, the Hymenoptera, *Corethra*, and *Miastor*, the provisional cavity in the disc, which has no ultimate meaning, appears first of all. The scientific meaning of this provisional cavity, as well as of its out-

ward tegument, can be explained, I think, as follows: The fact that imaginal discs, formations homologous to ambulatory legs, are situated in the cavity of the larval body, in connection with the tracheæ and nerves, must undoubtedly be understood as a consequence of the compound process of the displacement of the imaginal disc from the surface towards the inner cavity along the tracheal tube or nerve. The larvæ of *Corethra*, *Miastor*, *Chironomus*, have the imaginal discs more on the surface of the skin than those of the ant (*Myrmica*). In the former larvæ, these formations are walled in by a comparatively less developed fold of the skin. In the larvæ of *Myrmica*, this deep fold is transformed into a well-developed bag, which, together with the leg of the imago, developing within it, is placed during a certain time within the cavity of the larval body, below its muscular, subcutaneous stratum. In these insects, after the leg is stretched outside, the bag enclosing it is atrophied, and has no ulterior meaning. If we represent to ourselves that the outside aperture, leading into the provisional bag, with the incipient leg of the ant, is closed, we obtain all the homological parts of the disc of an ant as compared to the disc of *Muscidæ* in the corresponding stage of development. That is, the part of the disc of the *Muscidæ* which I described as its outside tegument, becomes the homologue of the closed fold of the skin in the disc of the ant; the provisional cavity of the disc of *Muscidæ*, between its outer and inner tegument, is homologous to the cavity of the bag in the disc of the ant; the inner tegument of the disc of the *Muscidæ* and the thickening of the anterior half of the disc of the ant represent the beginnings of the leg of the imago, and are homologous formations. The phase of development of the imaginal disc of the ant, before it begins to project externally, when the extremity consists only of three provisional segments, and the corresponding phase in the disc of *Muscidæ*, entirely concealed within the cavity of the body, are remarkably alike anatomically, if we do not pay attention to the external opening in the disc of the ant. It seems very probable that, when the post-embryonal development of different insects is better investigated, embryological facts will be found, which will favor the view, explained above, of the imaginal disc of *Muscidæ* being comparable to the disc of the ant (*Myrmica*). I mean to say, that an intermediate stage of the imaginal disc will be found, during which it occupies in the full-grown larva a position similar to its position in the larvæ of *Muscidæ*, and has at the same time its outer integument and provisional cavity similar to those of the ant.

"The paired abdominal thickenings which appear on the sides of the abdominal segments in the larvæ of *Muscidæ* before the formation of the permanent abdominal segments of the imago are, I think, morphologically homologous with the thoracic imaginal discs, and may be called abdominal imaginal discs.

"The facts communicated by me concerning the formation of the ali-

mentary canal of the imago during the post-embryonal development induce us, first of all, to reflect on the question, What transformation does the entoderm of insects which undergo the so-called complete metamorphosis pass through from the very beginning of the life of such insects? For the solution of the question how many times the entoderm of such insects is changed, science unfortunately does not as yet possess sufficient data concerning the development of the entoderm during their embryonal development.

"If the supposition of some investigators, who look upon the abdominal depression very early visible in the blastoderm of *Hydrophilus*, *Apis*, etc., as a stomach (*gastrula*), proves to be correct, and if, secondly, my observations are verified, that, notwithstanding the presence of this provisional entoderm (*gastrula*), the final epithelium of the median intestine of the embryo may develop anew with the help of the epithelium of the anterior and posterior intestine, then we will be able to affirm with assurance that the imago of insects with a complete metamorphosis has a *tertiary* entoderm. On the contrary, if it become established as a scientific fact, that the stomach (*gastrula*) of insects is transformed directly into the entoderm of the median intestine of the larval embryo, then the entoderm of the imago of the above-indicated insects should be called *secondary*. There is a considerable array of facts in favor of both of these suppositions, but in order to obtain a final solution of this important morphological question, we must wait for more numerous observations on the development of the entoderm during the embryonal and post-embryonal periods.[1]

"As to the anterior and posterior intestine, it seems very probable that these portions of the alimentary canal of the imago of insects which have a complete metamorphosis are *secondary* formations."

Recent Books and Pamphlets. — On the Fishes of Northern Indiana. By D. S. Jordan. On the Genera of North American Fresh-Water Fishes. By David S. Jordan and Charles S. Gilbert. (From Proceedings of the Academy of Natural Sciences, Philadelphia.) 8vo, pp. 104.

Die Wanderheuschercke (Œdipoda migratoria Linn). Gemeinverständliche Darstellung ihrer Naturgeschichte, Lebensweise, Schädlichkeit, und der Mittel zu ihrer Vertilgung. Von Dr. A. Gerstäcker. Berlin. 1876. 8vo, pp. 67. Two colored plates.

Catalogue of the Lepidoptera of America North of Mexico. Part I. Diurnals. By William H. Edwards. Philadelphia, Pa. 1877. 8vo, pp. 68.

Antigeny, or Sexual Dimorphism in Butterflies. (From the Proceedings of the American Academy of Arts and Sciences, xii. 1877.) 8vo, pp. 8.

Bulletin of the United States Entomological Commission. No. 2. On the Natural History of the Rocky Mountain Locust, and on the Habits of the Young or Un-

[1] Paul Mayer, in his Ontogeny and Phylogeny of Insects, speaks of the gastrula-stomach of the embryo of *Platygaster*, without noticing that this stomach is simply a fold of the body of the embryo, separating its cephalic and caudal haloes. The embryo of *Platygaster* is a highly convenient object for observation, and I can say with assurance that in this case the primary entoderm is not formed through the invagination of the exoderm.

fledged Insects as they occur in the More Fertile Country in which they will hatch the Present Year. Washington, May, 1877. 8vo, pp. 15.

The Westminster Review on The Recent Origin of Man. By James C. Southall. (Extracted from the Methodist Quarterly Review for April, 1877.) 8vo, pp. 25.

Gar-Pikes, Old and Young. By Prof. B. G. Wilder. (Reprinted from the Popular Science Monthly, May and June, 1877.) 8vo, pp. 22.

The Growth of Children. By H. P. Bowditch, M. D. (From the Eighth Annual Report of the State Board of Health of Massachusetts. Boston. 1877. 8vo, pp. 51.

Annual Report of the Trustees of the Museum of Comparative Zoölogy for 1876. Boston. 1877. 8vo, pp. 47.

GENERAL NOTES.

BOTANY.[1]

ORCHIS ROTUNDIFOLIA Pursh. — This, after all, is the proper name for this rare species, which is likely to be more common, now that Mr. Pringle has found new stations in Vermont, where it abounds. From live plants sent by Mr. Pringle to our Botanic Garden, the plant is now in blossom, and an examination of the fresh flowers reveals the fact that the plant is a genuine *Orchis*, having the glands in a pouch. In fact, it is a true congener of *O. spectabilis*, but with lateral petals spreading in the manner of most European species. It was Richardson who first referred this *Orchis* to *Habenaria*, and as he was aided by Robert Brown in the preparation of his Botanical Appendix to Franklin's Journey, one felt confident that all was right. Let our young botanists note from this how much is to be done, if they will but use their eyes. — A. GRAY.

THREE-FLOWERED SANGUINARIA. — From Galva, Illinois, H. W. Young sends a scape of *Sanguinaria Canadensis* which, besides the terminal flower, bears a pair of similar lateral flowers, one on each side, at some distance below, apparently without subtending bracts; an interesting and novel monstrosity. — A. GRAY.

TWO-FLOWERED ARETHUSA. — I found near here two days ago a remarkable specimen of *Arethusa bulbosa*, L. It was in a place where this species is not uncommon, but I have never seen so fine a specimen. There were two distinct scapes from the same bulb, one bearing a single flower, and the other a pair of flowers, all perfect and unusually fine ones. The scapes were not longer than is usual, but quite stout and healthy. — H. M. DENSLOW, New Haven, June 1, 1877.

In a package of several hundred fine specimens of *Arethusa*, just received from Plymouth, Mr. B. M. Watson has observed two interesting monstrosities. One of the specimens consists of a two-flowered scape, with the flowers complete and united at the base; the other has the flowers, which are both incomplete, united through nearly the whole length.

[1] Conducted by PROF. G. L. GOODALE.

Double Saxifrage, again. — At a recent meeting of the Academy of Natural Sciences of Philadelphia, Mr. Meehan exhibited a specimen of *Saxifraga Virginiensis* having double flowers. Subsequently Dr. J. G. Hunt exhibited a specimen of like character; both were collected on the banks of the Schuylkill River near Philadelphia. The flowers on each specimen were few in number, but of larger size than those noted by Professor Gray in the June number of the Naturalist. — Isaac C. Martindale, Camden, N. J.

Salix candida in Essex County. — I found this plant by accident in a swamp in Boxford, while on one of the local exploring trips last summer in company with J. H. Sears, who is familiar with that region. I had then the leaves only. This month we went again to the place and found male and female plants abundant in the vicinity of the *Pinus resinosa* grove. *Salix myrtilloides* grows there also, but this has been found also in North Reading, Andover, Danvers, and Hamilton. Oakes had *S. myrtilloides* from "Topsfield" in 1846.

I also send two varieties of *Draba Caroliniana*, discovered on Salem Neck by Dr. Charles Pickering in 1824. It grows abundantly some years, and is scarce others. There is an acre or two of it. One form is very white beneath the leaves, later flowered and lighter, and having thicker pods than the other, which is darker, with thin pods. Mr. Russell knew the place, and I have watched it every year since 1870. — John Robinson, Salem.

Sarracenia variolaris. — In 1874 I prepared notes on *S. variolaris*, in which it was stated, as one of the conclusions reached, that the sweet secretion at the mouth of the tubes was simply a *lure* to insects and *not* stupefying or intoxicating as had been supposed. Last year, having read an interesting article on this subject, in which the writer arrived at conclusions directly opposed to my own, I was curious to discover whether I had committed any error, but it was too late at that season to repeat former experiments.

On the 15th of this month, therefore, I procured about midday from a neighboring pine barren a number of leaves of this plant which were brilliantly colored and secreting freely. While still fresh, the upper portions of these leaves were cut off and slit open, thereby exposing the honeyed secretion on the internal surface, which was very abundant and glistening, sweet to the taste and viscid to the touch. These were then flattened out on a large newspaper, the whole surface of which was covered with them. Many house flies were soon attracted and commenced to feed, and I carefully watched their motions without any interruption for the space of one hour. The result was precisely as previously stated. In no instance did I discover the slightest unsteadiness or tottering in any of the flies, although I watched some of them feeding at one spot for at least ten minutes, at the expiration of which time they flew off apparently unhurt. They continued feeding and flying off from the

leaves during the hour I watched them, and certainly not one fell, nor was there any indication at any time of either stupor or intoxication.

These experiments I repeated in the same way on the 25th (but later in the day) and as carefully as on the previous occasion, and with precisely the same results; also on the next morning (26th) with plants which had been collected the day before, and these seemed to secrete still more freely. I ask, therefore, if flies and other insects are indeed intoxicated from eating the honey when they are *within* the tube, why should not the same intoxication result when the tubes are opened and flattened out? I conclude then (as I did before) that it is only the peculiar conformation of the leaf in its overhanging hood and internal slippery surface which entraps and finally destroys insects, and that the sweet exudation is only a *lure*, and *not* intoxicating in any way! I may remark that after flies and other insects slip and stumble, *if* they were indeed intoxicated or stupefied, it seems likely that they would remain at the lower portion of the leaf, and that their motions would be feeble and sluggish. On the contrary their efforts for escape are most active and vigorous, the flies flying and buzzing continually, and other insects incessantly climbing and falling back! It is only after being exhausted by their efforts that they eventually get slimed by the liquid at the base of the leaf, and stupor then overtakes them.

I have seen ants, and occasionally flies also, fall immediately as they entered the leaves before they could have eaten honey.

I remark further, that if this sweet internal secretion be stupefying, that outside on the wing (the "trail") must be equally so, and therefore insects ought to be found at the base of the leaves *on the ground!* I have never myself seen such, nor have I ever heard of any other persons observing dead or intoxicated insects *outside!* — J. H. Mellichamp, Bluffton, N. C.

Dr. Mellichamp sent, shortly after this communication, two phials of the fluid found at the bottom of the Sarracenia tubes. The bottle marked number one contained fluid collected in 1874;, it was clear and without much sediment. It was neutral in reaction. The fluid in the other bottle (number two) was collected partly from the still unopened leaves, at a time when "no rain had fallen for near two weeks." This fluid was turbid, had very little if any taste, and was slightly acid in reaction. Experiments by Mr. B. M. Watson and Mr. Hancox in our Botanical Laboratory confirmed, in the main, the following interesting statement by Dr. Mellichamp: "Pour out a teaspoonful or two of the fluid in an ounce measure, or a small wine-glass. Throw in a fly so that his wings will be wet or slimed. He will in a few minutes cease to struggle and will appear as if dead. Take him out after a while and let him dry, and in about half an hour he will revive." Number one proved to be nearly or quite inert. Number two was very active. The detailed results of Mr. Watson's experiments, which are still in progress, may be published in the August Naturalist.

Botanical Papers in Recent Periodicals. — *Flora*, No. 10. Batalin, Mechanism of the Movements of Insect-Eating Plants. H. G. Holle, On the Activity of Assimilation in *Strelitzia reginæ* (continued in Nos. 11 and 18). No. 11. F. V. Thümen, Notes on "Mycotheca Universalis." H. Leitgeb, On Bilaterality of Prothallia. No. 12. Dr. George Winter, Lichenological Notices.

Botanische Zeitung, Nos. 17, 18, and 19. H. Hoffmann, Experiments on the Culture of Variable Forms of *Achillea Clavennæ*, *Aquilegia vulgaris*, *Avena orientalis*, *Hordeum trifurcatum*, *Papaver Rhœas*, *Plantago alpina*, and *P. maritima*, *Polygonum amphibium*, *Rumex scutatus*, *Silene rupestris*, *Triticum turgidum*. Dr. J. Peyritsch, With Reference to the Ovular Theory. No. 20. Dr. H. Banke, The Development of the *Ascomycetes*.

ZOÖLOGY.[1]

The Mountain Boomer, or Showtl. — This name is applied in Oregon to the *Aplodontia leporina*, or "Sewellel," a rare rodent of the Pacific coast. According to Dr. F. S. Matteson, of Coquille, Coos County, Oregon, "the animal in question is found living in communities, and burrowing into the dry hills and mountain spurs in the 'burns' of this region. It is called 'mountain boomer,' and makes a kind of booming noise. It is also called 'mountain beaver,' as in its appearance and burrowing habits it remotely resembles the beaver. It is a vegetarian, subsisting most probably on barks and roots, and is a rarity even here, being exceedingly shy and difficult to catch." We add the following account by Dr. Matteson in his own words: —

The showtl inhabits the western slope of the "Coast Range" of mountains, from Puget Sound to California. He is a digger *par excellence* and burrows into the sides of the hills, usually in the neighborhood of a spring. He is patriarchally social, and settles his progeny around him, often forming quite a community. He is of a retiring disposition, choosing the deep recesses of the mountains for his home, and appears to understand intuitively that the white man is to him an undesirable neighbor. He is herbivorous, and is supposed to subsist upon the roots and succulent stems of annual plants, chief among which is the mountain fern, which usually grows luxuriantly near the spot which he selects for his burrow. When the rainy season, which is our winter here, comes, he retires to his under-ground domicil, first covering the entrance with the leaves and stalks of the fern, and proceeds to enjoy himself in the bosom of his family until the return of spring. Whether he really hibernates or not is a disputed point with the showtl sharps of this region, but the weight of authority appears to favor the views of the hibernationists. I know that I have never been able to procure any specimens in winter, and those of early spring are remarkable for seediness, as though a

[1] The departments of Ornithology and Mammalogy are conducted by Dr. Elliott Coues, U. S. A.

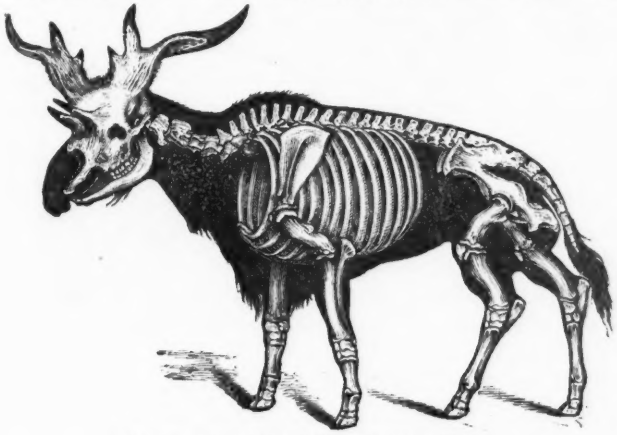
square meal were among the dim recollections of his past. On the contrary those caught in the autumn are fat, sleek, jolly-looking fellows, like the rest of the inhabitants of this valley.

This animal is called by the people here "marmot," and "mountain beaver," from his slight resemblance to the beaver; but he is more generally known as mountain boomer, from his habit, as it is said, of making a kind of booming noise. And this is all the information I have in regard to his cry or voice.

I am told that his flesh is excellent food, and that the Indians eat him freely, but it has never been my fortune to come into possession of a sample on which I cared to experiment in that direction.

He is seldom seen abroad, being very shy, and is trapped by setting a small steel-trap in the mouth of his hole. But he is exceedingly wary about "putting his foot in it," and, having several entrances to his subterranean dwelling, prefers to go and come by another door, and thus cheat the greedy trapper of his intended victim. He is accredited with being a fightist when captured and goes for his captor savagely, but when caught in a trap, even by a foot only, is usually found dead when the trap is visited. He appears to have no object in life except to dig holes, and eat fern roots. He does no harm, or good either, to the settler or anything else, for that matter. He is neither useful nor ornamental, and the sole purpose of his creation appears to be to furnish a rare and queer animal for curious naturalists to place in their collections. — F. S. Matteson, M. D., Coquille, Coos Co., Oreg., November 29, 1876.

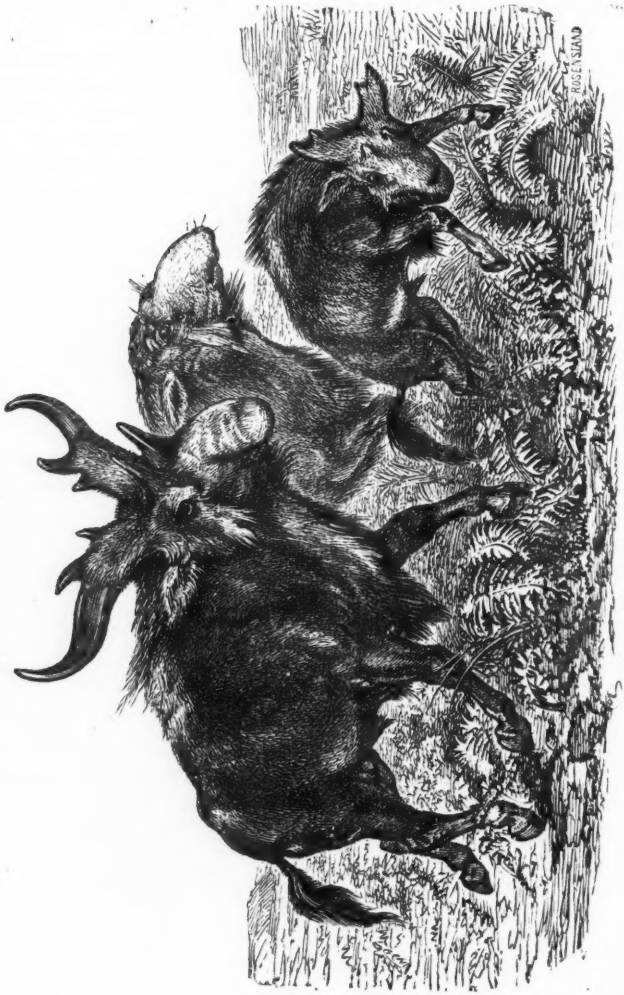
Restoration of the Sivatherium. — Most of our readers have probably never met with the accompanying figures restoring the gigantic



(Fig. 81.) RESTORATION OF THE SIVATHERIUM.

ruminant of the Himalayas, which we copy from the Danish *Tidsskrift*. This was a Tertiary, probably Miocene, "elephantine stag, having four horns and probably a long proboscis, being in some points between the

stags and the Pachyderms. It is supposed to have had the bulk of an elephant and greater height." (Dana's Manual.)



(Fig. 82.) RESTORATION OF THE SIVATHERIUM.

ANTHROPOLOGY.

ANTHROPOLOGICAL NEWS. — The *Journal* of the Anthropological Institute, for January, is very largely devoted to Polynesian subjects. The following papers are published in full: Notes on a Collection of Skulls from Mallicollo and Vanikoro, by Geo. Busk. Notes on the Nicobar Islands, by W. L. Distant; Signor S. M. D'Alberti's Expedi-

tion to New Guinea, by A. W. Franks; On the South Sea Islanders, by W. L. Rankin. Several papers are devoted to British archæology. M. Van der Horck contributes a paper on the Laplanders, and the Rev. W. Harper treats of The Tribes of British Guiana.

An elaborate, illustrated work on the archæology of Finland has lately been published in Helsingissä, by Johann Reinhold Aspelin. The title is Suomalais Ugrilaisen Muinaistutkinnon Alkeita.

Matériaux for January contains the usual amount of information concerning local explorations. In addition to this is a review by Montelius of the history and antiquities of Sweden, and of Pinart's Tumuli in Vancouver's Island.

Nature of February 15th contains a letter from Mr. Gerald S. Davies on the Obsidian Cutters of Melos. This is an interesting account of a series of obsidian cores and flakes from the Island of Melos, some having a "singular wavy pattern on the back ridge."

The French Anthropological Society has been authorized to open an international exhibition in the central palace of the Trocadero. M. Quatrefages has been appointed chairman of the commission.

We take great pleasure in welcoming to our fraternity of ethnological laborers Mr. Albert S. Gatschet, of Weimar. The following of his papers have come under our notice: Twelve Idioms spoken in the Southwest of North America, Weimar, 1876, 8vo, pp. 150; Indian Languages of the Pacific States and Territories, in the *Magazine of American History*, March, 1877; and Analytical Report of Eleven Idioms spoken in Southern California, Nevada, and on the Lower Colorado River, their Phonetic Elements, Grammatical Structure, and Mutual Affinities, in Lieut. Geo. M. Wheeler's Annual Report, 1876. In the same report will be found the following anthropological papers in addition to the one mentioned above: Report on the Operations of a Special Party for making Ethnological Researches in the Vicinity of Santa Barbara, Cal., with an Historical Account of the Region explored, by H. C. Yarrow, M. D.; Notes upon the Ethnology of Southern California and the Adjacent Regions, by Dr. O. Loew; and On the Physiological Effects of a very Hot Climate, by the same author. The amount of human remains, mortars, ollas, etc., found at one locality, described in Dr. Yarrow's paper, was so immense that they named it the Big Bonanza.

The American Geographical Society has recently published Major J. W. Powell's paper, entitled Outlines of the Philosophy of the North American Indians. The major divides the subject as follows: Introduction: Savagery as Ethnic Childhood; Cosmology: System of Worlds, Heavenly Bodies, Meteorological Phenomena, Geographical Phenomena-Remarkable Facts in Nature, Important Facts in Human Society; Theology: Beast Gods, Hero Gods, Daimon Gods, Firmament Gods, Tute ar Gods; Religion: Priestcraft, Prophets, Shamans, Witches, Ecstacism, Amuletism; Mythology.

In the *Western Review of Science and Industry* for February are the two following articles: The Missouri Mound Builders, by Judge E. P. West; and The Functions of the Uvula and the Prominence formed by the Azygos Uvulæ Muscles, by Thos. F. Rumbold, M. D. The last named is reproduced from the *St. Louis Medical and Surgical Journal.*

Mr. A. R. Grote contributes to the *Popular Science Monthly* a paper on The Early Man of North America.

In *Nature*, February 8th, Mr. A. W. Howitt, of Bairnsdale, Gippsland Victoria, adds something to his former notes on the boomerang. We are informed by Mr. Holmes, of Hayden's Survey, that the Moquis use their boomerangs for killing rabbits. A party of young men are detailed each morning to go hunting. Each one carries a bunch of these weapons slung over his shoulder. They shy them with great force and precision, but, of course, have no idea of their returning. Here, then, is the primitive boomerang, one step lower than the Australian, excelling the ordinary club by its more rapid flight, and by its following more strictly a plane of revolution.

In *Academy*, for February 24th, and March 3d, 10th, and 17th, will be found letters from Messrs. Sweet, Ellis, and Phillimore upon Spelling Reform. This subject becomes a very important one to the ethnologist at this time, when great interest is manifest in the collection of Indian vocabularies. It is a conceded fact, we believe, that, until the American Philological Association produces its phonetic alphabet, we must endeavor to record our vocabularies in such form that they can be reproduced at any printing-office.

Frequent references are made in European journals to the fact that many chipped arrowheads have a spiral form, as if to give a rotary motion to the arrow in its flight. In a conversation with Mr. Frank Cushing, the assistant of Dr. Rau, at the National Museum, who is also an expert at making flaked and chipped implements from bottle glass, etc., I asked him why he so often gave his points a spiral twist. He replied, "Because I cannot help it. When I hold the butt end of the arrowhead against the ball of my thumb, I have a good bearing, and can take off long flakes; but when I reverse the object to chip the other side, I have a poor bearing, and can take off only small chips. The same is true of the opposite edge, only the long chips will come from alternate sides, giving the point the appearance of a twist." Mr. Cushing has made thousands of chipped implements, and agreed with me that the twist or spiral was a necessity over which the savage had no intelligent control. Subsequently this undesigned improvement may have led to the alternate chisel-edge of some of Dr. Rau's specimens at the Centennial Exhibition.

The anthropological map accompanying Reclus' Nouvelle Géographie Universelle was prepared by M. G. de Mortillet. The palæolithic localities of France marked amount to 396. The neolithic localities comprise 26 natural caves, 144 artificial caverns, and 2314 dolmens.

GEOLOGY AND PALÆONTOLOGY.

Nature of the Legs of Trilobites. — Mr. C. D. Walcott has published a second paper in the Report of the New York State Museum, entitled Preliminary Notice of the Discovery of the Remains of the Natatory and Branchial Appendages of Trilobites. Over two hundred trilobites have furnished evidence of appendages, and all were found resting on their backs, so that Mr. Walcott concludes that they must have swum on their backs. (It may be noticed here that the larval *Limulus* nearly always swims on its back, as does the Phyllopod *Apus*.) He states that "they had a double row of appendages on each side of the central axis. The central or axial series were either the attachments of swimming lobes or rudimentary ambulatory legs. The lateral series were branchial in their structure, the bars serving as points of attachment for their lamellæ. It is probable that they were also used in swimming. Many sections show appendages beneath the head, but nothing satisfactory can be shown from them." He adds: "Additional evidence, obtained from sections of *Calamene senaria*, proves that the central or axial appendages were articulated to the thickened arches of the ventral membrane, on a line with the outer edges of the alimentary canal. The structure of the appendages, as shown in numerous microscopic, transparent, and opaque sections, leads me to the conclusion that they were the support of swimming lobes. What may have been a portion of the swimming lobe has been seen in several sections near the end of the appendage." These appendages terminate either in a round, blunt point, or else appear as if crushed. The form and outline of the swimming lobe could not well be preserved. Transverse sections display the ventral membrane between the axial appendages, the space occupied by the alimentary canal, and the axial and branchial appendages. The axial are but one third the length of the latter. The perfect state of preservation of the delicate branchial appendages and the ventral membrane precludes the idea of the destruction of anything of a stronger texture than fleshy swimming lobes attached to the axial appendages. The axial appendages could not have reached to the surface upon which the edges of the pleuræ rested, which negatives the view of their being in any way ambulatory in case the non-presence of articulations in the appendages should be called in question. The axial appendages of each series approximate each other near the posterior end of the hyportoma. What may be called oral appendages extend out between the hyportoma and the dorsal shell, or else they were articulated to a membrane connecting the hyportoma and dorsal shell of the head.

GEOGRAPHY AND EXPLORATION.

The Geographical Work of the United States Geological and Geographical Survey of the Territories. — Mr. A. D. Wilson, chief topographer of Hayden's Survey, gives in the Bulletin of the

Survey an interesting sketch of the mode of carrying on the geographical work of the Survey, showing the evidence on which the final maps prepared by the Survey rest. The primary triangulation was in charge of Mr. James T. Gardner until the autumn of 1875, when, on his resignation, the work was continued by Mr. Wilson. To give some idea of the amount of work that has been done by the topographical corps in the Survey of Colorado, it may be stated that it has established 1280 topographical stations within an area of about seventy thousand square miles, and from each station all the surrounding country was sketched. Mr. Wilson's assistant made over one thousand pages of profile sketches during the field season of 1875, each page being six by ten inches, while he himself made some five hundred pages of drainage sketches, and took the thousands of angles that were necessary to locate all the points. The high order of the work done, added to the difficulties and dangers under which geographical labor is performed in the most mountainous and wild section of our country, reflects credit upon our government in authorizing and sustaining such undertakings.

Geographical News. — *The Geographical Magazine* is publishing an account of the Official European Cartography in 1875–76, which possesses a good deal of interest. Among recent books of travel are Cameron's Journey across Africa; Canoe and Camp life in British Guiana, by C. Barrington Brown; The Cradle of the Blue Nile, by E. A. De Cosson; Peru in the Guano Age, by A. J. Duffield. Baron von Richthofen's new work on China is ready for publication. An eruption of Mauna Loa, the great volcano of Hawaii, took place on February 14th, in a new district. The lava probably came from the summit-rent, and traveled to the coast by subterranean passages.

MICROSCOPY.[1]

Zentmayer's Turn-Table. — Mr. Zentmayer has recently contrived a turn-table on which the slide is self-centred for width, by the absurdly simple device of bringing its two sides up to the opposite sides of a couple of brass pins equally distant from the centre of rotation. The adjustment for length is made by hand, guided by circles on the brass plate, or for slides of standard size by a pin at one end. The slide may be of any reasonable width, and can be easily and instantly decentred for refinishing old slides. The table is mounted with a clamp for attaching it to a table, though it can be furnished on a heavy block in the usual manner, if desired.

Microscopy at Nashville. — At the Nashville meeting of the American Association for the Advancement of Science, commencing August 29th, and continuing about one week, special arrangements will be made for the care of instruments and for the convenience of those who wish to use them. The local sub-committee having charge of these arrangements consists of Dr. T. O. Summers, Jr., and Profs. G. S. Blackie

[1] Conducted by Dr. R. H. Ward, Troy, N. Y.

and Alex. Winchell, who will leave nothing undone that is believed to be for the advantage of this department. As microscopy has been made a permanent sub-section, it is now, in reality, a national society of microscopists, with power to elect officers and continue its organization from year to year, and to avail itself of the great facilities and advantages of meeting with, and as members of the American Association. It was the unanimous and earnest desire of the members present at the last meeting, at Buffalo, that all the microscopists of the country, and especially the officers and members of microscopical societies, should take a hearty interest in the enterprise, and contribute to its usefulness by attending the meetings when possible, and sending contributions to be read if unable to attend personally. Circulars giving particulars of the arrangements for this meeting can be obtained from Dr. T. O. Summers, Jr., of Nashville, chairman of the local sub-committee, or from the editor of the microscopical department of the NATURALIST.

SHELL-SAND FROM THE BERMUDAS. — C. C. Merriman, of Rochester, N. Y., whose name we have had occasion to mention before in these pages, has just returned from a few months' visit at the Bermuda Islands, where he has gathered some quite remarkable specimens of shell-sand, composed almost entirely of foraminifera. It is interesting not only as a beautiful object under the microscope, but as being the material of which the islands are formed. In favorable conditions of winds and tides it may be gathered on the sand beaches quite fresh from the ocean, in which case the shells and corallines and sponge spicules are in great part unbroken, and many of them beautifully colored. Such conditions, however, occur quite rarely, as Mr. Merriman was able on two days, only, of his visit to make perfectly satisfactory collections. He has contributed a set of six exceedingly interesting and beautiful slides to the "Postal Club." Slides or material for the same can be obtained from him in exchange for any really interesting or valuable slides or material.

DETECTION OF CRIMINALS BY HAND MARKS. — In a very instructive lecture on the uses of the microscope, delivered at Washington, on April 30th, by Mr. Thomas Taylor, Microscopist of the Department of Agriculture, a view was presented on the screen showing the markings on the palms of the hands and tips of the fingers, and the important suggestion was made that the microscope might be used to effect in the detection of criminals by comparing the marks of a murderer's hands or fingers, which are often impressed in blood stains on the weapons used, with impressions in wax taken from the hands of accused or suspected persons.

ORGANISMS IN ROCHESTER HYDRANT WATER. — The Hemlock Lake water supply of the city of Rochester must be of extraordinary purity, if its ordinary condition is represented by the observations of Prof. S. A. Lattimore of that city, who examined it for the sake of detecting the

cause of the fish-like odor which it possessed last fall. In filtering large quantities of the water he scarcely obtained more than one or two grains of residue from a thousand gallons of water. Of this a large proportion consisted of small particles of clay and sand, and the balance was mainly composed of Diatomaceæ (*Cyclotella operculata*, *Melosira varians*, *Asterionella formosa*, *Fragilaria capucina*, *Navicula cuspidata*, and *Amphora ovalis*), Desmidiaceæ (*Closterium lunula*, and *Staurastrum gracile*), Oscillatoriaceæ (*Oscillatoria autumnalis*), Palmellaceæ (*Botryococcus braunii*), and Entomostraca (*Anurea heptodon*, *Cyclops quadricornis*, *Cypris tristriata*, and *Cetochilus septentrionalis*). Chemical analysis equally indicated the unusual purity of the water, and gave no clew to the cause of its obnoxious odor. The experiment of placing a small quantity of the microscopic algæ from the filter in distilled water resulted in the production of the well-known odor, after covering the mixture from the air for a few hours, just as it had done in a precisely similar experiment by Prof. N. T. Lupton, of Nashville, Tenn., on the water supply of that city. This would strongly confirm the partially accepted belief that this odor, which so often annoys the residents of our cities, is due to some condition, probably the decay and decomposition of the algæ in the water. No remedy is known except exposure to the air, which soon removes the odor.

Powdered Sulphur. — Mr. H. G. Hanks presented at a recent meeting of the San Francisco Microscopical Society three slides illustrating the substitution of powdered sulphur for the more costly and pure sublimed sulphur. Sublimed sulphur presents under the microscope a well-marked appearance of globular particles and botryoidal and stalactitic masses, while the powdered sulphur, which appears the same to the naked eye, is shown as angular fragments of irregular size. The powdered article when sold for the sublimed, should be regarded as adulterated, since it contains foreign matter.

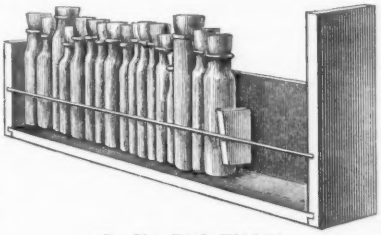
Exchanges. — Diatoms from Coorongite, from South Australia, for good mounted objects. Address Galloway C. Morris, East Tulpehocken Street, Germantown, Phil.

SCIENTIFIC NEWS.

— Every one who has occasion to use collections of small animals in alcohol knows the inconvenience of handling a large number of little bottles that will neither stand upright nor be still on their sides. If they are kept in boxes a large number have to be taken out one by one to find any particular bottle, and if they are set upon shelves the front ones are sure to be upset while searching among those in the rear. In taking care of a collection contained in several thousand bottles of this kind, the writer has been forced to contrive some method of arranging

them in a small space, and at the same time so that each bottle can be quickly found when wanted, and finally had a case of drawers made which has served the purpose so well that he has thought it worth while to describe it for the benefit of those having charge of similar collections.

One of the drawers is shown in the cut. (Figure 83.) The front, back, bottom, and one side are made of wood one quarter of an inch thick, while the other side consists of a single wire which keeps the bottles in place while allowing their contents to be easily seen. The drawers are a foot long and an inch wide outside, giving a space three quarters of an inch wide for the bottles, which may be from a dram to half an ounce in size. The bottles stand loosely in a single row, and if the drawer is not full, a wedge of wood or cork placed between the wire and the opposite side keeps the end bottles from falling over. The backs and sides of the drawers are made lower than the bottles so that the latter can be more easily taken out and put in. The fronts are made as high as the highest bottles likely to be used, so that when the drawers are placed side by side on a shelf they may close entirely the space between it and the shelf above, and cover the bottles from dust and light. If the width of the shelves is slightly less than the length of the drawers no knobs or handles are needed, and the fronts can be used for labels. The drawers being all of the same size can be changed from one part of the case to another, and the whole collection be rearranged and new specimens introduced in their proper places without changing the bottles from drawer to drawer. Drawers on the same plan might be arranged for bottles of any size not too heavy, and specimens in alcohol be stored in them much more compactly than in the ordinary closets and trays, and at the same time be more easily examined and more quickly found when needed. — J. H. EMERTON.



(FIG. 83.) VIAL HOLDER.

— A new publication designed to elucidate the natural history of Illinois is the Bulletin of the Illinois Museum of Natural History. No. I. contains the following papers: List of Illinois Crustacea, by S. A. Forbes, with a Key; The Tree in Winter, by F. Brendel; Sodic Pinate as a Test for Lime, by J. A. Sewall; Partial Catalogue of the Fishes of Illinois, by E. W. Nelson; Upon Parasitic Fungi, by T. J. Burrill; A List of the Orthoptera of Illinois, by Cyrus Thomas.

— Packard's Half Hours with Insects,[1] which was originally issued in twelve numbers, has lately been published in book form. We desire to correct some typographical and other errors of importance. Page 187, in explanation of Fig. 187, for Bucculating *read* Bucculatrix. Page

[1] Boston: Estes and Lauriat. 1877. 12mo, pp. 384. Illustrated. $2.50.

289, line 23, for *Disippus* read *Archippus*, and in line 25, for *Archippus* read *Disippus*. Page 305, line 13, for *sumac* read *cottonwood*, and on page 306, in explanation of Figure 236, for *sumac gall* read *vagabond gall*.

— L. Prang & Co., Art and Educational Publishers, Boston, Mass., announce the publication of The Yellowstone National Park, and the Mountain Regions of Portions of Nevada, Idaho, Colorado, and Utah. Described by Professor F. V. Hayden, Geologist-in-charge of the U. S. Government Expeditions to the Yellowstone Valley of the Years 1871 and 1872, and of the U. S. Geological and Geographical Survey of the Territories, and Illustrated by Chromo-Lithographic Reproductions of Water-Color Sketches taken by Thomas Moran.

— It is proposed to invite governmental geological surveys, learned societies, and private individuals, throughout the world, to send to the International Exhibition to be held at Paris in 1878 such collections as will make the geological department of that exhibition as complete as possible. In order to take advantage of the collections which may thus be brought together it is moreover proposed to convoke an International Geological Congress, to be held at Paris at some time during the Exhibition of 1878, and to make that congress an occasion for considering many disputed problems in geology. All American geologists interested in this project are invited to communicate with Prof. T. Sterry Hunt, Boston, Mass.

— Among recent zoölogical discoveries of interest is a new species of *Echidna* from New Guinea; a second species of that interesting lizard, *Sphenodon*, in one of the New Zealand Group; a new Leptocardian fish allied to Amphioxus, from Australia, named by Dr. Peters, *Epigomethys cultellus;* while the Persian deer (*Cervus maral*) is regarded by Dr. Severtzoff as identical with the Wapiti (*Cervus Canadensis*).

— A bed of pink coral has been discovered by the captain of the U. S. steamer Gettysburg, on her passage from Fayal to Gibraltar, in latitude 36° 30′ N., longitude 11° 38′ W. The least depth found was 30 fathoms, but the captain has no doubt that the coral comes to the surface at some point near the anchorage. Twenty miles west of the bank a depth of 16,500 feet was found, between this and Cape St. Vincent, 12,000 feet. The bank is rich in valuable coral of light pink shades. Full details of the discovery have been sent by the commander of the Gettysburg to the Navy Department, Washington, by mail.

— Professor F. de Hochstetter, formerly geologist of the Novara Expedition, and a distinguished investigator of the geology of New Zealand, has been appointed Superintendent of the Museum of the Imperial Geological Institute of Austria, and intrusted with its reorganization according to the plan approved by his Majesty. The construction of the new Museum of the Institute is in full progress. Mr. Francis Foetterle, the Vice-Director, has recently died, aged 53 years. He was attached to the Institute since its foundation in 1848.

— A Lyceum of Natural History has been established at Indianapolis, with Prof. E. T. Cox as President, and Mr. H. E. Copeland as Recording Secretary. At the first meeting after organization communications were made by Profs. John Myers, H. E. Copeland, and D. T. Jordan. The latter described the habits of a grasshopper destructive to corn and cotton in the Gulf States, while Professors Jordan and Copeland reported the discovery of the food of the Menomenee, or deep-water white fish of Lakes Superior and Michigan, fresh-water snails (*Physa* and *Limnæa*) having been found in the stomachs. We regret to announce that Mr. Copeland has, since the receipt of this notice, died.

PROCEEDINGS OF SOCIETIES.

Philosophical Society, Washington. — January 14, 1877. Mr. Gilbert, of Mr. Powell's Survey of the Rocky Mountain Region, read a paper on the Lake Bonneville basin, of which Great Salt Lake is the residue. Outlets to the north had been supposed on theoretical grounds to exist by several geologists, but he believed no one had published any actual identification of an outlet up to the present time. Such an outlet had been examined by him during the past summer, being a narrow cut through a mountain pass, of which the lower portion was formed through part of a bed of limestone while the upper portion of the banks were of gravel, inclined about 30°. The bed of the old channel now formed a continuous marsh. The old beaches which had been traced for many miles differed in level between the northern and southern limits as much as five hundred feet, the distance being about three hundred miles. The southern beaches were higher than those at Salt Lake and the northern ones lower, if observations by the aneroid barometer could be relied on. The speaker thought that this indicated a sinking of the land toward the north since the Glacial epoch, and taken in connection with the changes of outlet at Lake Winnipeg and elsewhere, he considered that it might be inferred that a general sinking of all northern land had taken place since that period.

February 10, 1877. Dr. Billings described some details of the methods employed in investigating the questions of the production of living organisms *de novo*, in suitable fluids from which external germs were excluded, and the "germ theory" of disease. He described a simple and apparently effectual method for protecting the fluid in a wine glass, for instance, by covering the glass with a watch-glass of a little larger diameter, with the convex side upward, the downward curvature of the edges of the watch-glass preventing the lateral introduction of currents of air and germs between the glasses, while the actual access of air was not interfered with. It is of course necessary to destroy anything which might adhere to the glasses before using, by exposing them to a very high temperature.

Major Powell spoke on the philosophy of the North American Indians. The speaker called attention to the fundamental difference in modes of thought which characterize the savage and the civilized man, and illustrated it by numerous examples.

We must, if we would fully understand Indian philosophy, leave that realm of thought where the sun is a great orb swinging in circles through the heavens, where the winds drift in obedience to cosmic laws, where falling stars reveal the constitution of the heavenly spheres, and pass to a lower realm where the sun is regarded as a little beast cowed by the heroic mien of a rabbit, and in very fear compelled to travel on an appointed trail through the firmament, where the wind is but breath, foul or fair, ejected from the belly of a monster, and where the falling star is but the dung of dirty little star-gods.

The savage philosopher believes in a system of worlds (not globes, but localities of existence), the world of this life and the world or region to which he will proceed hereafter. Among the lower tribes these worlds are arranged horizontally or topographically: the world of the hereafter is beyond some river, sea, cañon, chasm, or mountain range, and there is no world of the past, the progenitors of man having come out of the sea or from burrows in the ground. Their hereafter-land is reached by a bridge, a ferry, or a dangerous mountain pass.

Among the higher tribes the worlds are arranged vertically, a world or worlds below and others above. In this stage there is also a past world, that is, humanity came to existence from another land, situated sometimes above, sometimes below; but the righteous always goes in an opposite direction from that by which he came. These worlds communicate by magical ladders. The sun and moon are always personages; meteorological phenomena, acts of persons or of personified animals. All geographic phenomena, remarkable facts of nature, and the habits and customs of savage man, — the origin of all is known, and there is nothing that is not explained in their philosophy.

The theology or system of gods of the North American Indians is not fetichism, though there are many survivals from the fetichistic stage of thought. The gods of all the nomadic tribes are animals, for in all animal nature the nomad sees things too wonderful for him, and from admiration he grows to superstitious reverence, and the animals become his gods. His veneration for the past, so highly developed in the savage, modifies this theology, for it is not the animals of to-day that he reveres, but their ancient prototypes, a god for every race or species of animal. Man is not sharply separated by this system from other animals, but the heroes of the past are the hero-gods of to-day, while the race of man is partly superior, partly inferior to the animal races. Places have their genii or daimons, and all have unlimited power of self-transformation. The generic term for god in most Indian languages is ancient. Individuals,

clans, and tribes have their own special tutelary deity, whose image is their badge or totem.

The land of want, in their hereafter, is always open; there go the bad souls. The conditions of admission to the land of plenty are vague and variously fixed. There the few living righteous will meet the many good who have died in the past. Who are the good and who the bad? Their standards are as different from ours as their ideas of meteors. The bad man may be he who failed to sacrifice to his tutelar deity the spleen of the last elk killed; or he who slept on his back the night before the battle, when his gods had taught him to sleep on his belly. It is certain that the Indian philosophy is a stage of progress and not a degeneration of monotheism. Nor does it proceed from classical polytheism, in which human attributes were deified, nor that earlier kind where the forces and phenomena of nature were deified. Their myths are not symbols. The Indian gods are animal gods, and the Indian religion zoölatry, a development from fetichism.

February 24th. Mr. G. K. Gilbert, of Major Powell's Survey, read a paper on Geological Investigations in the Henry Mountains of Utah. These mountains stand in the midst of a plateau region, and form several groups or subgroups, the structure of which is exposed by erosion and denudation. They were formed by an upward flow of lava through horizontal strata, which flow did not reach the surface, but apparently severed the connection between two layers and intruded itself between them in the form of a mound or low cone, the superincumbent strata being forced up without fracture in the form of a dome which reached an angle at the sides of some sixty degrees. The superincumbent strata have been largely removed by natural causes. The facts were very remarkable and not yet fully explained. To these formations or subterranean lava cones he had applied the name of *laculites*.

Boston Society of Natural History. — February 21st. Mr. C. S. Minot read a paper on the Systematic Position of the Trematodes, and Mr. Scudder made a communication on "perfect" and "imperfect" metamorphoses of insects.

March 21st. Papers were read by Dr. T. M. Brewer, entitled Notes by Captain Bendire on the Birds of Oregon; and by Mr. Scudder on Polymorphism of our Blue Butterflies.

Appalachian Mountain Club, Boston. — February 14th. Osgood's White Mountain Guide Book was discussed and criticized. Mr. George Dimmock described a trip to Mount Mitchell, in North Carolina, and Miss M. F. Whitman a climb through Tuckerman's Ravine.

March 14th. Prof. J. H. Huntington read a paper on the Source of the Connecticut River.

American Geographical Society, New York. — March 13th. Dr. W. J. Morton lectured on South African Diamond Fields and the Journey to the Mines.

SCIENTIFIC SERIALS.[1]

Bulletin of the United States Geological and Geographical Survey of the Territories, vol. iii., No. 3. — Comparative Vocabulary of Utah Dialects, by E. A. Barber. Methods of making Stone Weapons, by Paul Schumacher. On a Peculiar Type of Eruptive Mountains in Colorado, by A. C. Peale. Report on the Geology of the Region of the Judith River, Montana, and on Vertebrate Fossils obtained on or near the Missouri River, by E. D. Cope. Palæontological Papers, Nos. 1-5: Descriptions of Unionidæ and Physidæ collected by Prof. E. D. Cope from the Judith River Group of Montana Territory during the Summer of 1876; Descriptions of New Species of Uniones and a New Genus of Fresh-Water Gasteropoda from the Tertiary Strata of Wyoming and Utah; Catalogue of the Invertebrate Fossils hitherto published from the Fresh and Brackish Water Deposits of the Western Portion of North America; Comparison of the North American Mesozoic and Cænozoic Unionidæ and Associated Mollusks with Living Species; Remarks on the Palæontological Characteristics of the Cænozoic and Mesozoic Groups as developed in the Green River Region, by C. A. White. Precursory Notes on American Insectivorous Mammals, with descriptions of New Species, by Elliott Coues. Notes on the Ornithology of the Region about the Source of the Red River of Texas, from Observations made during the Exploration conducted by Lieut. E. H. Ruffner, by C. A. H. McCauley. Catalogue of the Land and Fresh-Water Shells of Nebraska, by S. Aughey. Notes on the Geographical Work of the United States Geological and Geographical Survey of the Territories, by A. D. Wilson.

The Canadian Naturalist, vol. viii., No. 4. — On the Preglacial Geography of the Region of the Great Lakes, by E. W. Claypole. Notes on the Appearance and Migrations of the Locust in Manitoba and the Northwest Territories, Summer of 1875, by G. M. Dawson. Notes on some Geological Features of the Northeastern Coast of Labrador, by H. Y. Hind. Note on Some Recent Changes of Level of the Coast of British Columbia and Adjacent Regions, by G. M. Dawson.

The Monthly Microscopical Journal. — May. The Various Changes caused on the Spectrum by Different Vegetable Coloring Matters, by T. Palmer. Microscopic Aspects of Krupp's Silicate Cotton, by H. J. Slack. The Modifications which the Egg of the [Hooded-Eyed] Medusa undergoes before Fecundation, by A. Giard.

The Geographical Magazine. — May. The Himalayan System by C. R. Markham. M. Potanin's Journey through the Altai Mountains. The Navigation of Smith's Sound as a Route towards the Pole, by G. S. Nares. Map of the La Kuga and of the Alexandra Nile, by H. M. Stanley.

[1] The articles enumerated under this head will be for the most part selected.